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FINAL REPORT

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3701 North Fairfax Drive
Arlington, VA 22203

C/o Richard M. Satava, MD FACS
DIRO/Biomedical Technology

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CONTRACTOR: New Leaf Systems, Inc.
999C- Edgewater Blvd Suite 179
Foster City CA 94404

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PRINCIPAL INVESTIGATOR: Jaron Lanier
P.O. Box 2842
Sausalito, CA 94966

PI TELEPHONE NUMBER: (415) 591-7881

SHORT TITLE: A Virtual Reality-Based Simulation of Abdominal Surgery

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TECHNICAL REPORT SUMMARY

Virtual Reality is a marriage between three dimensional computer graphics and complex dynamical simulation to produce a fully immersive, interactive environment. Users can move and interact in this environment as if they were actually a part of it. Medicine and surgery in particular have been identified as some of the most promising applications of this technology . Virtual reality systems can be used to teach surgical anatomy, diagnose surgical problems, plan operations, simulate and perform surgical procedures (telesurgery), and predict the outcomes of surgery. New Leaf Systems has developed a highly interactive simulation of open cholecystectomy in a fully immersive virtual reality.

Technical Problem

The goal of the project was to provide, on a rapid prototype basis, a working model of virtual abdominal surgery. The gall bladder has been selected as an appropriate organ for modeling both because of the high number of gall bladder procedures performed, and because of suitability of the relevant anatomy to the technology. The open rather than laparoscopic procedure was modeled for several reasons: Other projects are currently underway to model laparoscopic procedures. The open procedure lends itself to generalization to other procedures. Many surgical residents do not see an open procedure during their training until a problem has arisen in a laparoscopic cholecystectomy.

Methodology

A literature review was conducted covering surgical theory and practice for the cholecystectomy procedure as well as computer science research efforts in surgical simulation. In addition ongoing research projects in surgical simulation at other institutions were surveyed.

A procedural analysis of the open abdomen cholecystectomy operation was performed, in which the relevant anatomical structures and discrete surgical interactions were identified. The actually VR cholecystectomy simulation was then designed. Three dimensional models of organs, instruments, and the operating room environment were constructed in Swivel 3D Pro. Interactions were then designed in Body Electric. First library routines were put in place to map incoming data coming from the DataGloves and Tracker to the virtual head and hands in the 3D model. Interactions were designed to allow the hands to hold and actuate virtual tools, and for the tools in turn to act upon the virtual organs. Then the steps of the operation were implemented according to the procedural analysis. Many iterations were involved in this process. Three dimensional models were redesigned as new interaction requirements arose. Interactions were refined to balance visual accuracy with ease of use.

Technical Results

Subjects were drawn from several categories: two computer scientists, six middle and high school students, two doctors, one biomedical engineer, and one artist. All but one student were able to successfully complete the procedure within 15 minutes on their first trial. Average time to completion was 8.93 minutes. This was judged to reflect highly successful user interface design.

The surgeons evaluation was that the simulation was useful for medical students first learning the surgical procedure, who need to memorize the steps in the operation. They felt that tactile feedback and most importantly, accurate tissue deformation, was necessary for teaching surgical residents, who are expected to know the procedure and be working on specific techniques.

Non-surgeons including novice computer users and students found the simulation understandable. They were able to see and identify the anatomical structures involved and understand the steps in the procedure. Lack of stereopsis and tactile feedback made some target acquisition tasks more difficult.

Computer Scientists evaluating the system indicated that this was the most complex set of user interactions they had seen in a fully immersive virtual reality.

Implications for further research

Many questions remain about how virtual reality technology can best be used in medical education. after completion at New Leaf Systems, this simulation will be transferred to the University of California at San Diego Medical School's Learning Resources Center where it will be integrated into, and evaluated as part of their Multimedia System for medical education. While highly successful in meeting its original design challenges, this simulation needs several features in order to offer greater utility to surgeons and students. Chief among these are rendering of volumetric data (such as images from MRI scans) and tactile feedback. A second and third year contract with UCSD is contemplated in which these areas would be addressed.

APPARATUS

The simulation hardware system:

- Silicon Graphics Onyx Reality Engine
- Macintosh Quadra Work station
- Thin-net Ethernet between SGI and Mac
- Liquid Image Head Mounted Display
- VPL Right and Left DataGloves with Data Acquisition and Transmission Unit
- MacAdios Data Acquisition Board
- Ascension Flock of Bird Tracking system with three sensors (deployed to head and both hands) with large magnet
- Roland 220 Sampler for audio feedback

The Simulation Software:

- Body Electric 1.5.1
- Swivel 3D Pro 2.04
- Isaac 1.7.0
- Voice Navigator

The Simulation Data Files

The total simulation consists of many types of data. These data are stored in

- GB111 - A Swivel 3D Pro file of the 3D model (see appendix C for listing)
- GB111.DM - A Body Electric file of the Dynamics (see Appendix E for listing)
- gb.prop - Text file of Texture Map Configuration (See Appendix D for listing)
- Audio Sample files
  - Click
  - Breathing
  - Cut
  - Proximity
- Texture Map Files (.rgb extensions) individual bit-mapped images assigned to objects by gb.prop

```
pSideWall.rgb
sClockWall.rgb
Floor.rgb
pBackWall.rgb
Drape.rgb
sFat.rgb
HepLig.rgb
Belly.rgb
Stomach.rgb
GB.rgb
Pancreas.rgb
```

Liver.rgb

DESCRIPTION OF THE SIMULATION

Three Dimensional Model

Polygonal 3D geometric models of the anatomy, the surgeon's hands, and the OR environment were constructed primarily in Swivel 3D Pro on the Macintosh Quadra. One organ, the stomach, was imported from the SwivelArt anatomy collection developed by View Point. In addition, some modeling was done in MacroModel and imported to Swivel3D.

The objects in the simulation are rigid. Deformation, such as the stretch or shrink of the cystic duct under tension from the forceps pull, is accomplished by morphing or interpolating rendering between two end state forms: fully stretched or fully shrunk, in the case of the duct. Morphing behavior is controlled dynamically in real time by the Body Electric Dataflow network. Thus user action can trigger and control the degree of morph by their actions either directly on the organ object or by manipulation of a virtual tool which in turn acts on the object.

The models were rendered in real-time gauroud shading by Isaac on a Silicon Graphics Onyx Reality Engine. Texture maps are tiff (bit mapped) files, either created in Adobe PhotoShop (textures on the organs) or captured as video or PhotoCD images in the liver transplant operating room at the University of California , San Francisco, and edited in Adobe PhotoShop on the Mac.

Anatomical structures

- Liver
- Gallbladder
- GallBladder/Liver Fossa
- Cystic Duct
- Common Duct.
- Cystic Artery
- Hepatic artery
- Fatty Tissue
- Gastro-hepatic ligament
- Stomach
- Pancreas

The surgeon's hands, and surgical tools are fully interactive elements. The immediate operating environment, such as the lighting and OR surroundings are simulated to provide context and scale without compromising performance.

Components of the operating room environment

- Adjustable Operating Theatre Lamps - Both are interactive , grabbable solid model objects and local light sin the computer graphic lighting model. The simulation user can grab the lamp handle and readjust the lighting on the patient.

- Operating Table
- A simple body form is texture mapped with a photo-realistic belly skin image
- Body is draped with blue cloth, texture mapped with drapery
- Walls of the operating room are texture mapped with photo-realistic images from a real operating room

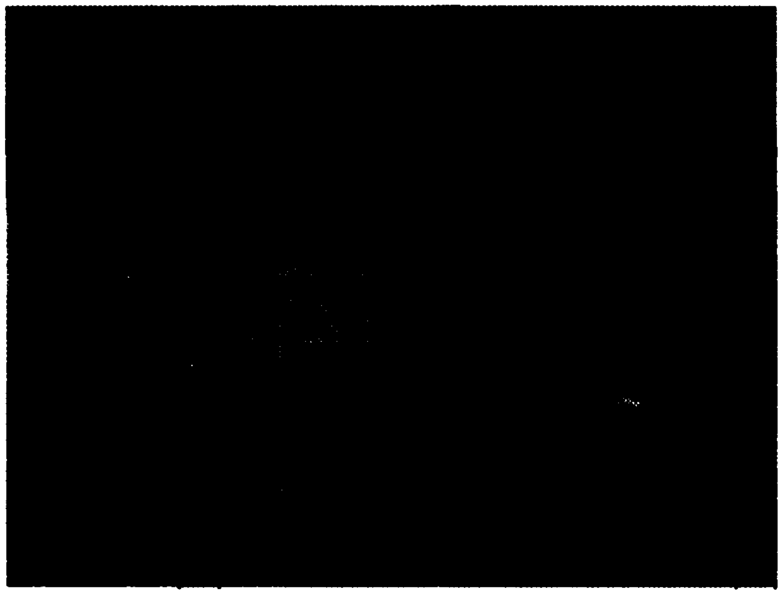

Figure 1: The virtual operating room showing texture mapped walls, floor, drapery,and belly

Dynamics

The interaction dynamics, or behavior, was designed in Body Electric, a visual programming language for virtual reality. Dynamics are the active behavior of the simulation based on user action. A listing of the Dataflow Modules (called DMs) comprising the network is included at the end of this report. Page one "GB111.DM" is the top net, in from which all of the nested DMs both for debugging and running the simulation are called. Subsequent nested DMs are listed after the DM from which they are called.

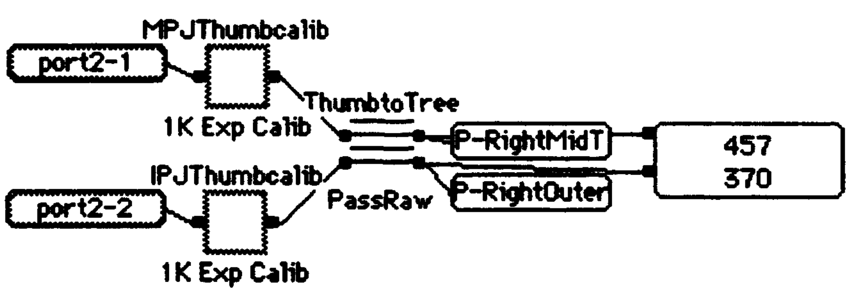

Figure 2: a portion of the Body Electric Data Massage (DM) network mapping inputs from the DataGlove (port2-1 and port2-2) to the joints of the thumb using exponential calibration

Interactions

In the real operating room, tools are placed in the surgeon's hand by a scrub nurse as they are requested. In the simulation, the user receives the tool by making a special tool request gesture (cupped hand, palm up) while giving a verbal command. Another gesture <exaggerated open hand> causes the tool to return to its storage position.

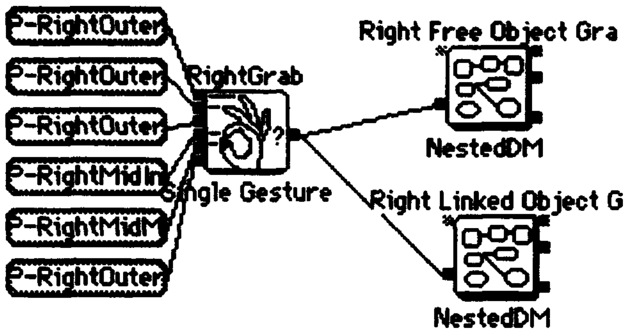

Figure 3: A portion of the Body Electric DM network defining which finger positions will be recognized as a "grab"

Gestures are transduced by the DataGloves and magnetic hand trackers and transformed by Body Electric into naturalistic motions of the virtual hands. Virtual tools are held in the hands and used to effect organs in the model. To obtain a tool, the user holds out the correct hand in the reception gesture and requests the tool verbally by name. Once grasped, tools follow the hand that holds them in both position and orientation. Forefinger flexion is used to direct the angulation of the virtual tool to give the user greater control. Thumb flexion is used to open and closed hinged tools such as scissors or clamps. Tools return automatically to their "home" position when released.

Figure 4: The virtual hands hold the kelly clamp

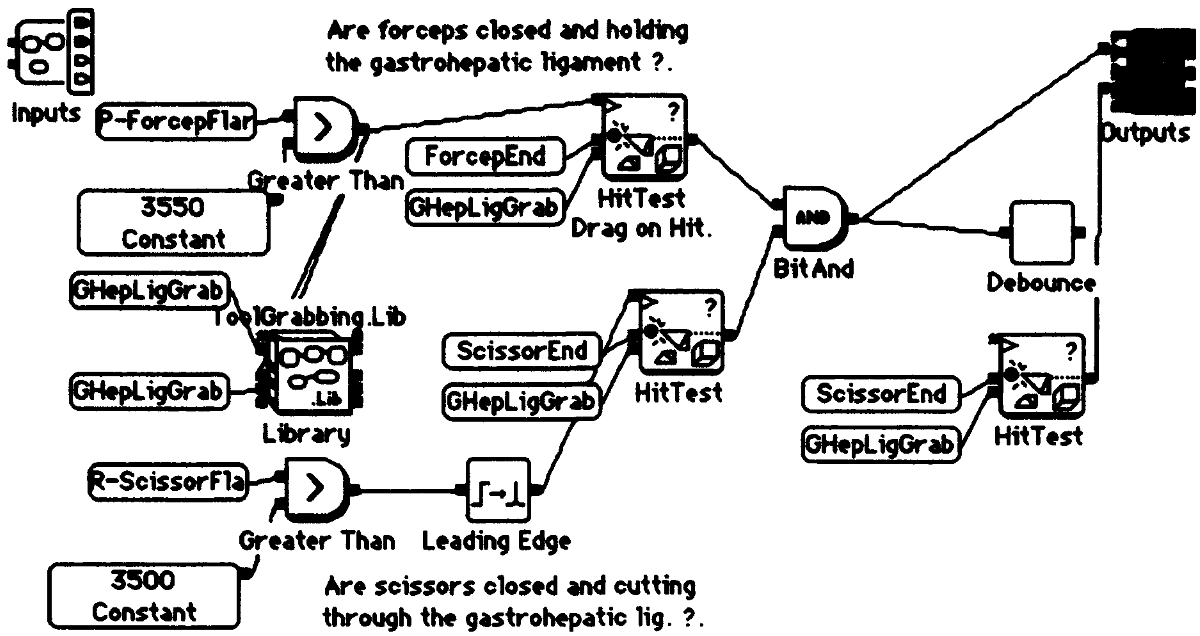

Figure 5: DM network controlling tool behavior. The HitTest DMs compare tool locations to that of their targets to see whether they are in position to be actuated.

Simple newtonian mechanics including gravity have been modeled. For example, a tool can fall when dropped, or sail across the room when thrown. During the actual procedure, however, this capability is generally superceded by the gesture control described above.

Tool interactions offer some significant challenges in the absence of force feedback or physical constraint on the user. A physical tool is subject to forces from both the hand that holds it and the organ or surface on which it acts and in turn applies forces to both the hand and the tissue. On selected portions of the model (the cystic duct and cystic artery, primarily) the deformation effects of these forces on the model are simulated by morphing the structure in question. The users own physical hands however remain unconstrained, and their position continue to be controlled by the output of the magnetic trackers. Therefore an elastic relationship between a tool and the hand is maintained when the tool has grasped a structure. If the user's hand moves farther away than is physically possible, the active part of the tool remains in position while its orientation follows the user's hand. Audio feedback is used to provide further information in the absence of stereopsis or tactile or force feedback.

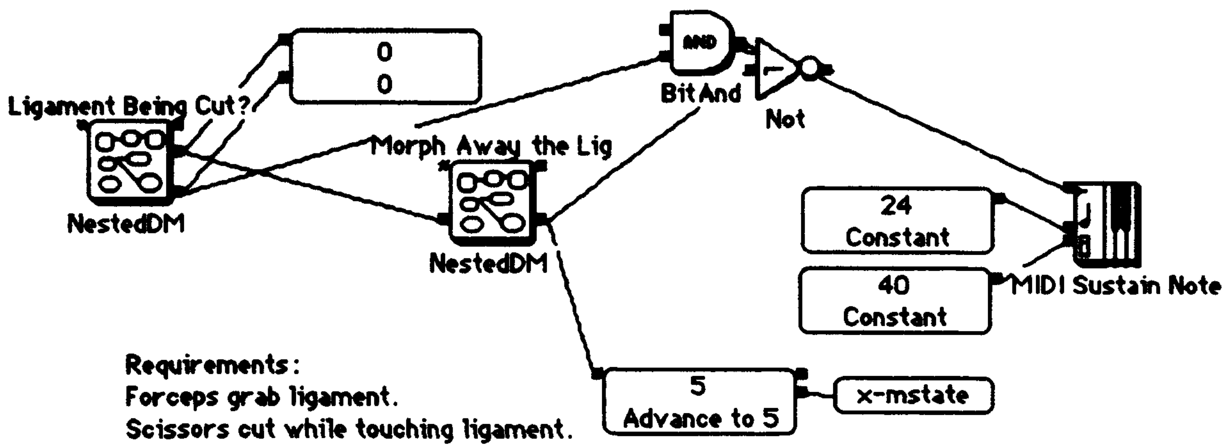

Figure 6: This DM network triggers audio feedback (the MIDI Sustain Note DM) when the Gastrohepatic ligament is cut with the scissors

Surgical tools in the simulation

- Scalpel: cuts the skin
- Abdominal wall retractor: currently unused
- Harrington ("Sweetheart") retractor: for retracting the liver
- Scissors: divides the hepatic ligament, cuts the cystic duct and artery
- Forceps: grasps the hepatic ligament, cystic duct and artery
- Right Angle Clamp: currently unused
- Clip Applier: applies clips to cystic duct and artery
- Kelly Clamp: grasps the gallbladder for dissection from the liver bed, and for removal from the abdomen
- Bovie Cautery: cauterizes the tissues connecting the gallbladder to the fossa or liver bed.

Speech Recognition

Speech recognition for tool request was implemented in Voice Navigator software. This proved to require significant time to train the system to recognize the requisite vocabulary for each participant. It also was not acceptably reliable. Therefore, for user trials, keyboard input from a human operator was used to replace machine recognition.

Audio Feedback

Four distinct sounds were digitally sampled and recorded using a Roland 220 Sampler, and are triggered for playback dynamically by events in the virtual world:

- Ventilated Breathing Sound (background noise for realism - potentially could be used for complications simulations by varying frequency).
- Proximity Cue Sound (used to indicate that the actuating tool end is within the prescribed boundaries of the target tissue.
- Cutting sound, also used for cautery
- Clip Application sound (Click)

Steps in the Simulation

The simulation requires that each step of the procedure be performed in the correct sequence. A detailed analysis of the surgical tasks and perceptual requirements was made as the basis for tuning the simulation to optimize system performance for resolution and frame-rate. Library Research , observation of actual surgery and input by Wendy K. Brown MD, surgical resident at Dartmouth Medical Cente,r were applied to determining the sequence. Subsequently, surgeons evaluating the system suggested further changes, some of which were implemented. The work product of this was a narrative description of each task in a normal open Cholecystectomy procedure. This document forms the script for interaction dynamics described below.

Step 1

Surgeon (user) extends right hand with cupped palm facing up, and states "scalpel", and the scalpel appears in the right hand. The incision is made by drawing the blade across the abdomen starting at an X mark. A proximity sound cue is given when the scalpel is in the right zone to make the cut. A red line appears to signify how far the cut extends. In this first implementation, the cut can be made in only one place. Future versions will offer more range.

Step 2

when the incision is complete, the abdomen morphs open (a computer graphic term which means that it automatically undergoes a transformation from the closed to the open state). Later versions may include more details of the actually retraction process. An Abdominal Retractor has been modeled, but is not currently employed.

Step 3

The liver is retracted up and out of the way either by the right hand or by the harrington retractor. The retractor is then set in place. Once positioned the retractor is stationary: held in place by an invisible virtual assistant. At this point the gastrohepatic ligament is visible and covering the lower portion of the Gallbladder.

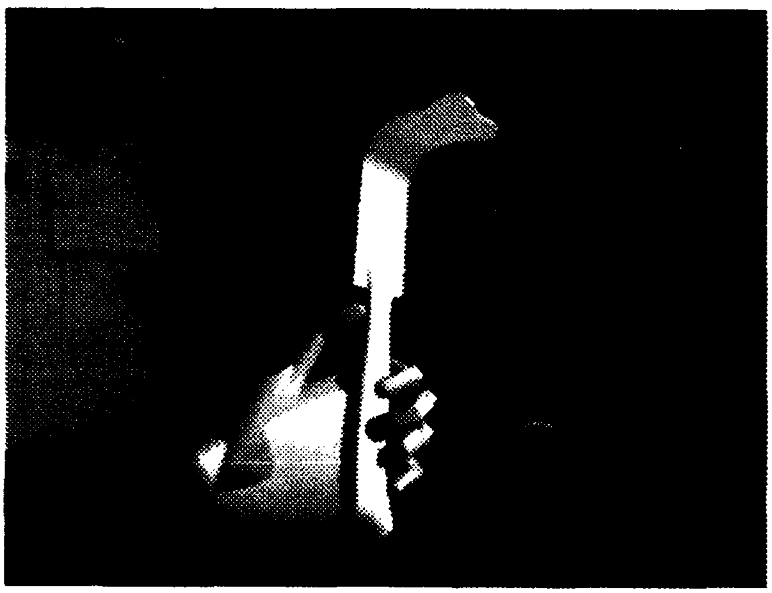

Figure 7 - The liver is held in place with this Harrington Retractor

Step 4

The user requests the scissors in the right hand and the forceps in the left, grasps the gastrohepatic ligament with the forceps, and then cuts it with the scissor. The proximity sound cue is given when the scissors are in the cut zone of the ligament. a second sound indicates actual cutting is taking place. As each cut is made, the ligament shrinks back somewhat.

Step 5

The fatty tissue obscuring the cystic artery, duct, and common bile duct is pushed out of the way using the tips of the forceps (still in left hand).

Step 6

The forceps are then used to grasp the cystic duct. This requires considerable skill, especially in the absence of stereopsis or tactility. The proximity sound cue is given when the forceps tip is in the grasp zone of the duct. When forceps closes on duct system, the duct follows the forceps tip within certain limits (so the user can get a sense of the system by moving it).

Step 7

The duct is held in the stretched position with the forceps in the left hand. The clip applier is requested in the right hand, and the two clips are applied by activating the applier with the thumb. The proximity sound cue is given when the clip applier tip is in the correct region on the duct. A distinct second sound indicates that a clip had been applied. Surgeons testing the system suggested that two or more clips be applied to the proximal end of the duct. One is sufficient for the distal end. This change may be implemented in future versions.

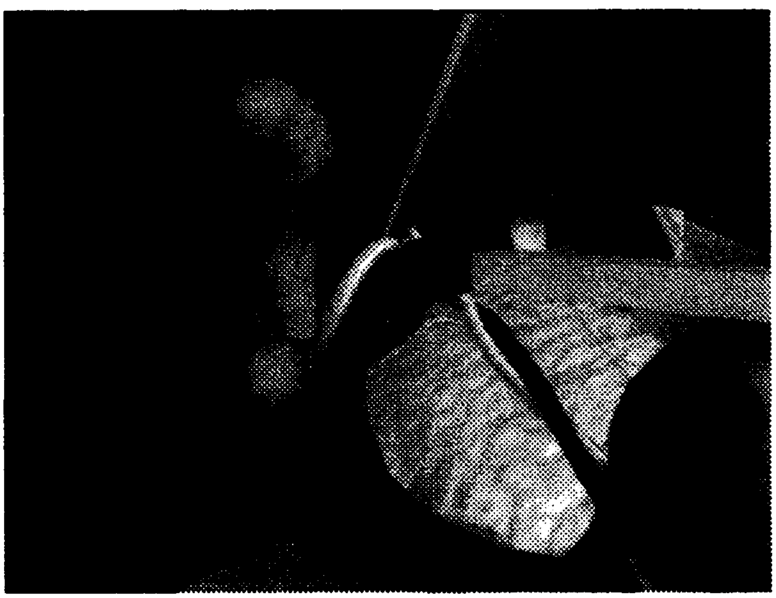

Figure8 - The clip applier prepares to place a clip on the cystic duct as the forceps hold it stretched taut.

Step 8

The clip applier is released, and the scissors are requested and used to cut the cystic duct between the clips. This cut can be made only between the clips. In future versions, erroneous cuts could be made, and consequences explored.

Step 9

Steps 7 and 8 are repeated for the cystic artery.

Step 10

Both scissors and clip applier are released. The Kelly clamp is requested in the left hand and the Bovie Cautery in the right hand. Using the cautery, the Gallbladder is separated from the bed . As the connective tissue is removed, the Gallbladder becomes free. The Gallbladder can be pulled about by the clamp demonstrating simple tissue deformation simulation.

RESULTS

Subjects

Subjects were drawn from several categories: two computer scientists, six middle and high school students, two doctors, one biomedical engineer, and one artist.

Evaluation of Results

Criteria evaluated were ability to successfully complete the procedure, time to completion and narrative evaluation. The latter, narrative evaluation, is considered to be the most meaningful criterion, especially in the case of evaluation by surgeons.

Time to Completion:

Average time Students	10:07
Average time MDs	11:36
Average time Researchers	5:28
Average time to completion All	8:93

Best Times were under 2 minutes.

The middle school and high school students

Perhaps most importantly, participation in the simulation offered an opportunity for the student to try on the role of surgeon, without the onus of real outcome or grades. The psychological gain may well be in the child's expanded view of self and possibilities. In addition , the students learned functional anatomy , the names of organs and were easily able to retain the sequence operative tasks. It is conjectured that the high degree of computer experience (including video games) make immersive simulation particular effective in training this group, and their somewhat older peers, now in college.

Medical/Professional Evaluation

Two Surgeons , Toshi Mori MD and Sunil Bhoyrul MD, and one biomedical engineer, Frank Tendick PhD, from UCSF used the system on May 18th, 1994. Their evaluation of the simulation was that it would be very useful for medical students first learning the surgical procedure who needed to memorize the steps in the operation. They felt that the level of realism was too low to be of use teaching surgical residents, who are expected to know the procedure and be working on specific techniques. This was especially true of certain aspects of the operation. For example, both indicated that the dissection of the gallbladder from the liver bed is a critical part of the operation. The connective tissue is simulated very simply. In fact its representation as a set of polygons linking the liver and gallbladder is almost more symbolic of the process than descriptive of it. This kind of abstraction can useful in procedural training = ie learning the steps required to perform the operation, but is probably not of value in learning the actual skill involved in safely performing the dissection. It has been suggested that this part of the procedure (dissection of the Gallbladder from the liver bed) is of such importance, it ought to be simulated separately in a great deal more detail.

Computer science Evaluations

Computer Scientists using the system were highly impressed by the number and complexity of individual interactions simulated. This was less apparent to doctors and students. both of whom tended to compare the simulation to the physical world with its limitless range of interaction potential. This points out a major difficulty in developing simulations - the need to define and support an acceptable level of complexity and variance in interaction, without overwhelming the system and the developers.

User Interface Issues

- Need for stereopsis: The current version of the simulation is monoscopic. This is a purely economic issue. The simulation contains all the necessary information to generate stereo views. but the Silicon Graphics Onyx lacks the video splitter internal card necessary to generate a second view NTSC video signal. The lack of stereopsis seriously impairs the user's ability to perform fine target acquisition tasks such as grasping a duct or artery with the forceps.

- Need for Tactile and force feedback: No tactile or force feedback devices were used in this simulation. Using audio and visual feedback concomitantly can offer some substitute for tactility. In the simulation, the proximity sound cue and the visual-spacial feedback from perspective and overlap of near object over far (the scalpel being obscured as it penetrates flesh. for example) combine to give orientation. However. a surgical simulation environment which would be useful for advanced training would require realistic force transduction and reflection. Audio feedback can give event information (occurrence of the sound signifies a state such as proximity or contact). In trying to substitute audio information for force . amplitude (loudness) may express degree of force , however. there is no clear mapping for the vector of the force.

- Need for more accurate deformation and other behaviors of tissues: Tissue deformation was only represented on a minority of structures in this simulation. Even within the limited confines of an immersive virtual reality environment such as this one further work can be done. A Simulation concentrating solely on specific surgical technique such as dissecting the gall bladder from the fossa or liver-bed. has been proposed and such concentration would allow greater accuracy of detail.

- Head-tracked immersion versus "through the window" simulation
  Tracking the user's head and hands transforms the experience from passive viewing to active participation. It may be the case that there are significantly different learning pathways invoked in an immersive environment *even when the experience is of relatively low resolution.* This is a subject for future research.

FUTURE WORK

In the next phase of the project, the simulation will be taken over by Dr. Helene Hoffmann and her colleagues at the UCSD Medical School Learning Resources Center. The LRC team has developed a comprehensive prototype of a multimedia system for medical education. In year one of the new contract, the open cholecystectomy simulation presented here will be integrated into the UCSD multimedia environment for further evaluation as a teaching system.

Among the teaching /learning issues to be evaluated are the discrimination between learning to operate the Virtual Reality interface (special gestures, symbolic actions) from learning which is directly or indirectly transferable to the performance of surgery . This includes addressing the question of whether such a system might teach negative habits.

Initial work will be performed using a "through the window" approach with a Stereographic monitor display. This simulation was developed in the Body Electric visual programming language. In subsequent years two and three, it is expected that that the simulation will be ported to Talisman, New Leaf's new virtual reality authoring language. The greater capacity of this tool will support integration of external simulations, alternative input and display devices and rendering and interaction with radiologically derived volumetric data sets. Head mounted and desk mounted, head-coupled displays will be used .

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Simulation Created by

The New Leaf Systems Team

Chuck Blanchard. . . . . Dynamics Design and Programming
Ann Lasko-Harvill . . 3D modeling and texture map images
Jaron Lanier. . . . . . Simulation Consulting
Charles V. Loucks . . Management
Tom Kiley. . . . . . .Oversight

The Gravity International Team

Dale John McGrew Dynamics and System Wizardry
Nathaniel Bletter . . . Sound
Rajat Paharia. . . . Dynamics Assistant
Ross Moran .. Dynamics Assistant
Jason Ambrose. . Dynamics Assistant

Medical Advisor, Wendy Brown, MD

Video Script and Direction by Ann Lasko-Harvill

Video Equipment And Camera Operation, Karl Dresden, KAPORETH Video

Music by Jaron Lanier

Video Production by Ethan Sing, Pacific Rim Media

Multimedia Environment video courtesy of UCSD Learning Resources Center

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TABLE OF APPENDICES

Appendix A - Literature Search

Appendix B - Images from the Simulation

Attached are Still images from the simulation

- The Operating Room and Draped "patient"
- Virtual hand holding Kelly Clamp
- Virtual hand holding Harrington Retractor
- Close up of the Clip Applier and Ducts prior to clip application
- Close up of the Clip Applier and Ducts after clip application

Appendix C - The Model

A hierarchical listing of the 3D model, attached details the linking between objects by tab indentation.

Appendix D - Listing of the Properties file

Appendix E - Listing of the Dynamics Dataflow Models

APPENDIX A - LITERATURE SEARCH

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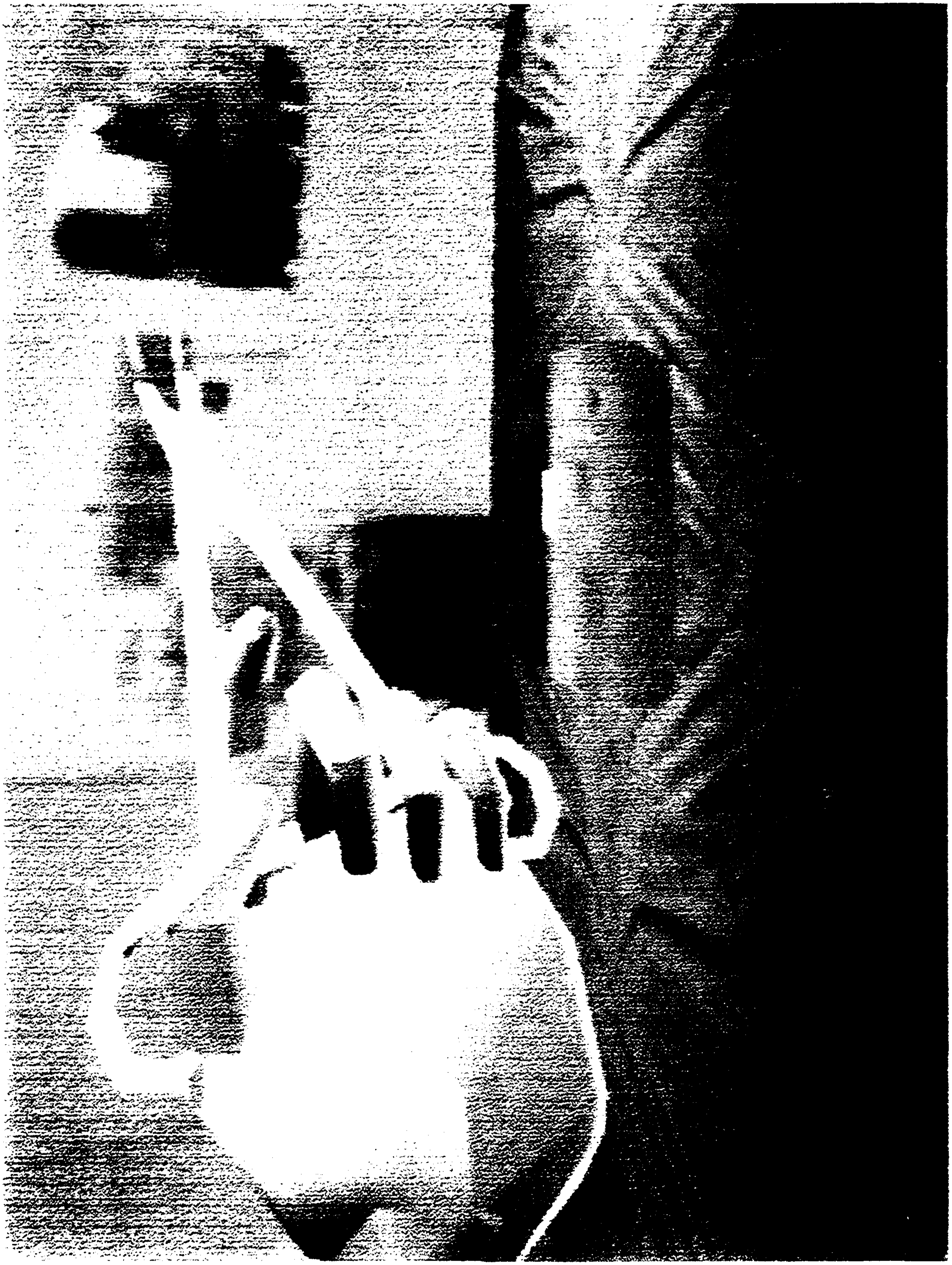
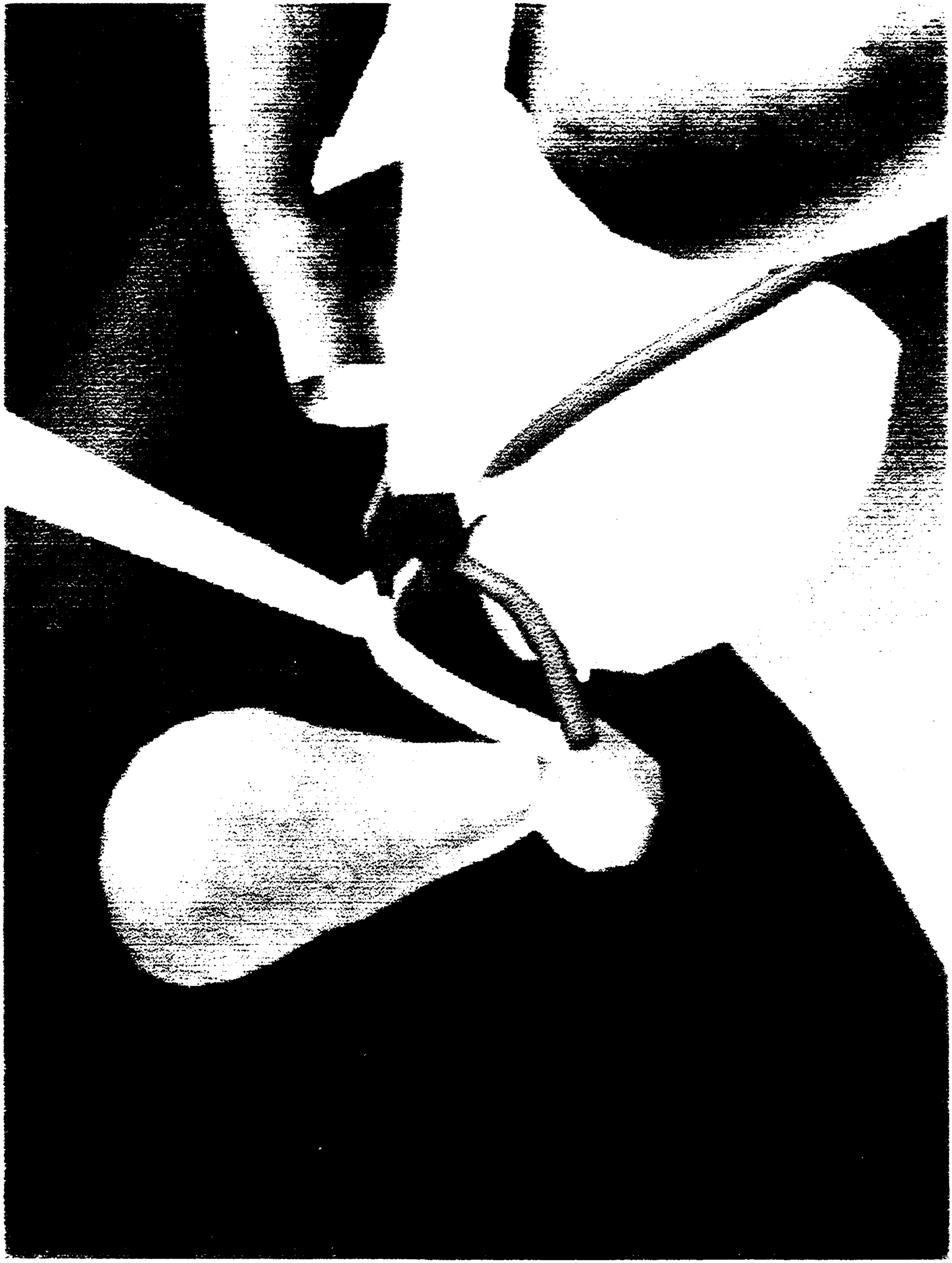
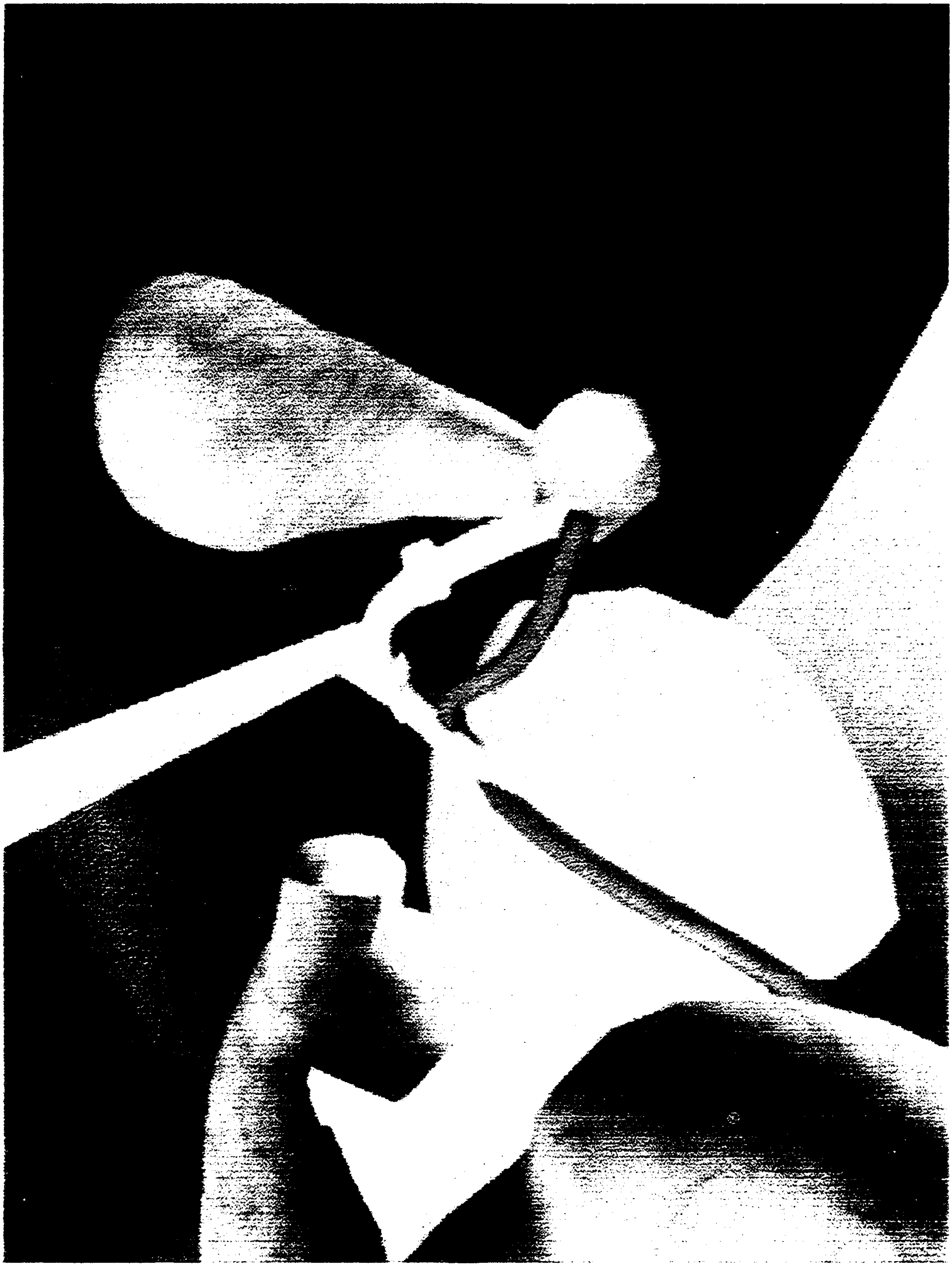
Appendix B - Images from the Simulation

Attached are Still images from the simulation

- The Operating Room and Draped "patient"
- Virtual hand holding Kelly Clamp
- Virtual hand holding Harrington Retractor
- Close up of the Clip Applier and Ducts prior to clip application
- Close up of the Clip Applier and Ducts after clip application







```
GB111
'<name>', x, y, z: yaw, pitch, roll.
   'World' 0, 0, 0 : 0.0, 0.0, 0.0
      'WestWall' 5433, 2219, -6621 : 270.0, 90.0, 270.0
      'EastWall' -8079, 2219, -6621 : 270.0, 90.0, 270.0
      'PolhmOffset' 20, 801, 1220 : 0.0, 0.0, 0.0
         'PolhmAdjust' 0, 0, 0 : 0.0, 0.0, 0.0
            'LeftHand' -229, -556, -507 : 347.7, 186.0, 169.3
               'LeftPalm' 10, 179, 129 : 0.0, 0.0, 0.0
                  'LeftMidPinkie' 90, 10, -225 : 0.0, 22.9, 0.0
                     'LeftOuterPinkie' 0, 0, -79 : 0.0, 13.4, 0.0
                        'LeftPinkieTip' 0, 0, -65 : 0.0, 6.7, 0.0
                  'LeftPalmGrb' 54, 43, -165 : 0.0, 0.0, 0.0
                  'LeftMidRing' 38, 12, -259 : 0.0, 16.9, 0.0
                     'LeftOuterRing' 0, 0, -90 : 0.0, 17.4, 0.0
                        'LeftRingTip' 0, 0, -74 : 0.0, 8.7, 0.0
                  'LeftMidMiddle' -19, 9, -264 : 0.0, 0.0, 0.0
                     'LeftOuterMiddle' 0, 0, -101 : 0.0, 23.7, 0.0
                        'LeftMiddleTip' 0, 0, -86 : 0.0, 11.9, 0.0
                  'LeftMidIndex' -76, 13, -237 : 0.0, 2.2, 0.0
                     'LeftOuterIndex' 0, 0, -102 : 0.0, 4.1, 0.0
                        'LeftIndexTip' 0, 0, -83 : 0.0, 2.1, 0.0
                           'LeftIndexEnd' -1, 0, -68 : 0.0, 0.0, 0.0
                  'LeftThumbBase' -50, 4, -38 : 319.0, 359.0, 326.0
                     'LeftMidThumb' 0, 0, -120 : 0.0, 11.9, 0.0
                        'LeftOuterThumb' 0, 0, -91 : 0.0, 4.0, 0.0
                           'LeftThumbEnd' 0, 0, -71 : 0.0, 0.0, 0.0
               'LeftHandDriver' 0, 0, 0 : 0.0, 0.0, 78.4
               'LeftHandArrow' 80, 106, 0 : 0.0, 0.0, 187.8
               'LeftCntr-WallVect' -220, 150, 10 : 0.0, 0.0, 0.0
                  'LeftHeadWallVector' 0, 0, -10 : 0.0, 0.0, 0.0
            'Head' 522, -1102, -1520 : 206.2, 171.5, 176.6
               'HeadPoint' 0, 850, 300 : 0.0, 0.0, 0.0
                  'LColorSmall' 67, 178, 0 : 0.0, 0.0, 0.0
                  'LColorSmall' -70, 180, 0 : 0.0, 0.0, 0.0
                  'RColor' 147, 176, 0 : 0.0, 0.0, 0.0
                  'LColor' -141, 180, 0 : 0.0, 359.7, 0.0
                  'Face' 0, -245, 84 : 270.0, 90.0, 270.0
                  'Ear' 0, -290, 140 : 0.0, 0.0, 0.0
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                'SoundFollow3' 560, -4510, -1430 : 126.5, 0.0, 0.0
                'SoundFollow4' 2240, -4390, 3420 : 72.0, 0.0, 0.0
                'SoundFollow5' 3920, -6390, 590 : 320.5, 0.0, 0.0
                'SoundFollow' -760, -740, -260 : 281.4, 0.0, 0.0
            'Eye' 0, -362, 428 : 0.0, 0.0, 0.0
        'HeadDriver' 0, 0, 0 : 0.0, 0.0, 0.0
        'NeckPt' 0, 1026, 0 : 270.0, 90.0, 270.0
    'RightHand' 1080, -268, -473 : 202.8, 107.4, 236.4
        'RightPalm' 10, 179, 129 : 0.0, 0.0, 0.0
            'RightMidPinkie' -79, 10, -225 : 0.0, 12.1, 0.0
                'RightOuterPinkie' 0, 0, -79 : 0.0, 15.4, 0.0
                    'RightPinkieTip' 0, 0, -65 : 0.0, 7.7, 0.0
            'RightPalmGrb' 54, 43, -330 : 180.3, 0.0, 0.0
            'RightMidRing' -30, 12, -259 : 0.0, 4.2, 0.0
                'RightOuterRing' 0, 0, -90 : 0.0, 19.6, 0.0
                    'RightRingTip' 0, 0, -74 : 0.0, 9.8, 0.0
            'RightMidMiddle' 27, 9, -264 : 0.0, 5.6, 0.0
                'RightOuterMiddle' 0, 0, -101 : 0.0, 31.0, 0.0
                    'RightMiddleTip' 0, 0, -86 : 0.0, 15.5, 0.0
            'RightMidIndex' 85, 13, -237 : 0.0, 8.5, 0.0
                'RightOuterIndex' 0, 0, -102 : 0.0, 38.3, 0.0
                    'RightIndexTip' 0, 0, -83 : 0.0, 19.2, 0.0
                        'RightIndexEnd' -1, 0, -68 : 0.0, 0.0, 0.0
            'RightThumbBase' 50, -4, -38 : 41.0, 359.0, 34.0
                'RightMidThumb' 0, 0, -120 : 0.0, 12.3, 0.0
                    'RightOuterThumb' 0, 0, -91 : 0.0, 3.9, 0.0
                        'RightThumbEnd' 0, 0, -71 : 0.0, 0.0, 0.0
        'RightHandDriver' 0, 0, 0 : 0.0, 0.0, 78.4
        'RightHandArrow' 80, 106, 0 : 0.0, 0.0, 187.8
        'RightCntr-HeadWallVec' -220, 150, 10 : 0.0, 0.0, 0.0
            'RightHeadWallVector' 0, 0, -10 : 0.0, 0.0, 0.0
'SimpleHeadHand_b07_2H' 0, 0, 0 : 0.0, 0.0, 0.0
    'GrbHitSoundVar' 0, 0, 0 : 0.0, 0.0, 0.0
    'GrbGestureSoundVar' 0, 0, 0 : 0.0, 0.0, 0.0
    'FlySpeedLimit' 270, 0, 0 : 0.0, 0.0, 0.0
    'Finger' 42, 270, 75 : 352.6, 352.1, 350.3
'Bigger' 0, 0, 0 : 0.0, 0.0, 0.0
    'globals' 80, 80, 0 : 0.0, 0.0, 0.0
        'LEFT_TOOL' 10, 80, 0 : 0.0, 0.0, 0.0
```

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    'RIGHT_TOOL' 10, 100, 0 : 0.0, 0.0, 0.0
    'mstate' 15, 80, 0 : 0.0, 0.0, 0.0
    'debug' 0, 0, 0 : 0.0, 0.0, 0.0
    'status' 0, 0, 0 : 0.0, 0.0, 0.0
    'morphon' 0, 1, 18700 : 0.9, 0.0, 0.0
      'morphSkinL' 100, 1, 100 : 0.0, 0.0, 0.0
      'morphSkinR' 100, 1, 100 : 0.0, 0.0, 0.0
      'morphGHepLig' 100, 10, 100 : 0.0, 0.0, 0.0
      'morphBloodLine' 100, 10, 100 : 0.0, 0.0, 0.0
      'morphDWhole' 100, 10, 100 : 0.0, 0.0, 0.0
      'morphArtWhole' 100, 1, 100 : 0.0, 0.0, 0.0
  'Camera' 14, 6, -20 : 14.4, 259.2, 0.0
  'SloppyTool' 80, 80, 0 : 0.0, 0.0, 0.0
    'ObjCenter' 68, -252, -504 : 12.7, 42.0, 24.5
      'ObjTEnd' 0, 0, 0 : 0.0, 0.0, 0.0
        'ObjTGrab' -1, -2, 549 : 357.8, 2.6, 225.2
    'VirtToolGrab' 517, -475, -445 : 257.9, 21.8, 283.6
      'VirtToolEnd' 1, 32, -550 : 278.7, 54.9, 203.3
  'Floor' 170, 2160, -270 : 270.0, 270.0, 270.0
    'NorthWall' 5326, -6426, 59 : 180.0, 0.0, 90.0
    'Tray' 1300, 1217, -1640 : 0.0, 0.0, 270.0
      'RAClampBase' 310, 770, -140 : 270.0, 0.0, 90.0
      'ClipApplierBase' 330, 380, -180 : 270.0, 0.0, 90.0
      'ForcepBase' 260, 50, -140 : 270.0, 0.0, 90.0
      'KellyBase' 270, -290, -140 : 270.0, 0.0, 90.0
      'ScalpelBase' 270, -680, -140 : 270.0, 0.0, 90.0
      'Tray2' -160, -2540, 0 : 0.0, 0.0, 0.0
        'OrganBowl' 58, 360, 0 : 0.0, 180.0, 90.0
        'ScissorBase' 150, -266, -140 : 270.0, 0.0, 90.0
        'BovieBase' 350, -77, -140 : 92.0, 0.0, 0.0
        'HarringtonBase' 320, -110, -140 : 270.0, 0.0, 90.0
        'AbdWallRetractorBase' 110, -410, -140 : 270.0, 0.0, 90.0
    'Table' 423, -124, -1960 : 180.0, 325.7, 180.0
      'Drape' -473, -65, -182 : 180.0, 0.0, 180.0
      'Body' -700, 235, 560 : 0.0, 0.0, 270.0
        'BodyNew' 0, 0, 0 : 0.0, 0.0, 0.0
          'GHepLigGrab' 171, 285, -72 : 180.0, 0.0, 85.8
            'FatSlide1' -86, 80, 90 : 32.8, 347.8, 139.2
              'FatLayer1' -139, 2, -32 : 289.8, 73.1, 275.3
                'FatGrab1' -97, -22, 76 : 97.5, 86.0, 263.2
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    'HepGastLig' 41, -59, 8 : 149.4, 275.2, 145.8
      'WholeLig' 0, 0, 0 : 0.0, 0.0, 0.0
      'MorphLig' 0, 0, 0 : 0.0, 0.0, 0.0
  'Thorax' 305, 274, -311 : 180.0, 0.0, 90.0
    'skinR' 0, 0, -41 : 270.0, 0.0, 0.0
      'SkinRClosed' 0, 0, 0 : 0.0, 0.0, 0.0
      'SkinROpen' 0, 0, 0 : 0.0, 0.0, 0.0
      'cutMark2' -394, 0, 342 : 268.8, 0.0, 270.0
    'skinL' 0, 0, -41 : 270.0, 0.0, 0.0
      'SkinLClosed' 0, 0, 0 : 0.0, 0.0, 0.0
        'cutMark' 398, -234, 4 : 270.9, 16.8, 313.9
      'SkinLOpen' 0, 0, 0 : 0.0, 0.0, 0.0
    'Line' -2, -32, -510 : 90.0, 0.0, 0.0
      'LineCutPt' 111, 297, 0 : 270.0, 348.5, 0.0
      'MorphLine' 0, 0, 0 : 0.0, 0.0, 0.0
        'ShortLine' 0, 8, 8 : 269.5, 0.0, 0.0
        'WholeLine' 0, 8, 8 : 270.0, 0.0, 0.0
    'Blood' 0, 0, 332 : 0.0, 0.0, 0.0
  'Stomach' 337, 1, -72 : 48.0, 335.4, 209.6
  'Artery' 273, 142, -126 : 96.2, 337.4, 119.9
    'HepaticArtery' -55, 1, -23 : 138.5, 340.3, 139.6
    'ArtCut' 24, -39, 23 : 36.9, 289.5, 105.1
      'ArtCutB' 13, -18, -88 : 68.1, 337.2, 22.3
      'ArtCutA' 0, 0, 0 : 0.0, 0.0, 0.0
    'ArtWhole' 24, -39, 23 : 36.9, 289.5, 105.1
      'WholeFlat' 0, 0, 0 : 0.0, 0.0, 0.0
        'ArtAnchor' 67, -12, -28 : 48.2, 4.9, 0.3
          'ArtPull' -87, -8, 9 : 90.0, 351.0, 15.3
      'WholeBent' 0, 0, 0 : 0.0, 0.0, 0.0
        'ArtClipGrab2' 18, -28, -100 : 67.6, 347.8, 270.0
          'ArtClip2' -1, 8, 0 : 11.8, 26.2, 10.4
        'ArtClipGrab1' -6, -3, -38 : 174.4, 8.6, 107.6
          'ArtClip1' 3, 3, 0 : 180.0, 4.6, 36.2
  'Duct' 259, 174, -87 : 79.6, 332.7, 126.9
    'CommonDuct' -67, 34, -27 : 106.2, 339.5, 27.2
    'DCut' 0, 0, 0 : 359.4, 289.0, 58.4
      'DCutB' 13, -18, -88 : 68.1, 337.2, 22.3
      'DCutA' 0, 0, 0 : 0.0, 0.0, 0.0
    'Whole' 0, 0, 0 : 359.4, 289.8, 58.4
```

```
                'DWholeFlat' 0, 0, 0 : 0.0, 0.0, 0.0
                   'DuctAnchor' 40, -6, -49 : 50.7, 340.6, 356.9
                      'DuctPull' -45, -1, 9 : 90.0, 347.8, 356.3
                'DWholeBent' 0, 0, 0 : 0.0, 0.0, 0.0
                   'DClipGrab2' 40, -26, -81 : 88.1, 337.1, 321.8
                      'CysticClip2' -12, -9, 6 : 177.5, 8.8, 6.6
                   'DClipGrab1' -6, 0, -35 : 175.5, 1.6, 74.4
                      'CysticClip1' -2, 3, 0 : 181.8, 358.9, 1.4
          'Pancreas' 78, 593, -98 : 272.9, 31.7, 339.1
          'LiverRotate' 383, 184, -120 : 5.7, 120.0, 182.6
             'GBRotate' 0, 0, 0 : 0.0, 355.0, 1.3
                'gallbladder' -1291, -512, 421 : 131.1, 325.9, 33.0
                   'BallBladder' 8, 115, 19 : 119.6, 47.7, 28.9
                   'DummyParent' -35, 126, 16 : 25.4, 199.0, 166.1
                      'CysticClipDummy' -33, -24, 81 : 154.9, 11.9, 45.3
                      'ArtClipDummy' -24, -47, 104 : 326.4, 344.9, 292.4
                      'ArtCutDummy' -19, -43, 116 : 323.8, 345.6, 33.5
                      'DCutDummy' -24, -14, 106 : 338.1, 337.1, 22.4
                   'BallJoint' 2, 104, -4 : 158.3, 0.0, 358.3
                   'GBEndHit' 0, -59, 0 : 0.0, 0.0, 0.0
             'Liver' 2, -80, 48 : 101.2, 357.7, 155.7
                'LiverGrab' -19, 122, 128 : 0.0, 349.2, 291.8
                'Fossa' -12, 30, -8 : 270.0, 165.0, 0.0
                   'AFosHit' 0, 0, 0 : 90.0, 89.0, 270.0
                      'BFosHit' 0, 0, 0 : 46.0, 0.0, 0.0
                         'CFosHit' -4, 0, 4 : 46.0, 0.0, 0.0
                            'DFosHit' 54, 2, 3 : 43.0, 0.0, 0.0
                               'EFosHit' -3, 0, -5 : 49.0, 0.0, 0.0
                                  'FFosHit' -2, 0, 0 : 46.0, 0.0, 0.0
                                     'GFosHit' 0, 0, 0 : 44.0, 0.0, 0.0
                                        'HFosHit' 26, 0, -4 : 12.7, 0.0, 0
                                           'HFos-dummypt' 8, 8, 0:0.0, 0.0
                                           'HFos' 1, 2, -45 : 359.1, 15.0,
                                        'GFos' 1, 2, -45 : 359.1, 15.0, 0.
                                     'FFos' 1, 2, -45 : 359.1, 15.0, 0.0
                                  'EFos' 1, 2, -45 : 359.1, 15.0, 0.0
                               'DFos' 1, 2, -45 : 359.1, 15.0, 0.0
                            'CFos' 1, 2, -45 : 359.1, 15.0, 0.0
                         'BFos' 1, 2, -45 : 359.1, 15.0, 0.0
                      'AFos' 1, 2, -45 : 359.1, 15.0, 0.0
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'AbdWallRetractor' -1480, 380, -1537 : 0.0, 0.0, 0.0
   'AbdWallHit' 0, -65, 207 : 0.0, 0.0, 0.0
   'AbdWallBlade' 0, -62, 195 : 90.0, 359.7, 0.0
   'AbdWallRetractorHome' 0, 0, 0 : 0.0, 0.0, 0.0
'HarringtonGrab' -565, -319, -1116 : 169.0, 326.6, 358.6
   'Harrington' -250, 265, -156 : 108.8, 0.0, 180.7
      'HarLiverHit' -24, -144, 250 : 180.0, 0.0, 0.0
      'HarringtonHome' -512, -147, -1020 : 129.6, 0.0, 0.0
      'HarringtonBlade' 0, -62, 195 : 90.0, 359.7, 0.0
         'HarringtonEnd' 70, -58, 0 : 90.0, 0.0, 0.0
   'HarringtonVars' 0, 80, 0 : 0.0, 0.0, 0.0
'BovieGrab' -1140, 383, -1298 : 0.0, 0.0, 0.0
   'Bovie' 0, 32, -280 : 180.0, 0.0, 0.0
      'ButtonOn' 0, -28, -151 : 315.0, 270.0, 314.9
         'ButtonOff' 0, 0, 0 : 0.0, 0.0, 0.0
         'ButtonHit' 0, 0, 0 : 0.0, 0.0, 0.0
      'BovieHome' 7, -35, -281 : 0.0, 0.0, 0.0
      'Bovieshaft' 0, 0, 0 : 0.0, 0.0, 0.0
         'BovieEnd' -2, 0, 453 : 225.0, 90.0, 135.0
   'BovieVars' 0, 80, 0 : 0.0, 0.0, 0.0
'ScissorGrab' -1328, 384, -1496 : 0.0, 0.0, 0.0
   'Scissor' -40, 40, -200 : 0.0, 270.0, 0.0
      'ScissorFlare' 67, 0, 0 : 180.0, 0.0, 350.0
      'ScissorEnd' 18, 228, 0 : 0.0, 0.0, 0.0
      'ScissorHome' 32, -199, -44 : 0.0, 0.0, 0.0
   'ScissorVars' 0, 80, 0 : 0.0, 0.0, 0.0
'ScalpelGrab' 792, 379, -1218 : 0.0, 0.0, 0.0
   'Scalpel' 0, 40, -480 : 180.0, 0.0, 0.0
      'ScalpelBlade' -22, 0, -4 : 270.0, 270.0, 270.0
         'ScalpelEnd' 2, -156, 0 : 90.0, 0.0, 0.0
      'ScalpelHome' 2, -39, -481 : 0.0, 0.0, 0.0
   'ScalpelVars' 1, 80, 0 : 0.0, 0.0, 0.0
'KellyGrab' 1175, 380, -1212 : 0.0, 0.0, 0.0
   'Kelly' 0, 40, -400 : 0.0, 270.0, 0.0
      'KellyFlare' 5, 0, 0 : 180.0, 0.0, 335.0
         'KellyEnd2' 4, 178, -26 : 90.0, 2.0, 0.0
      'KellyFlare2' 8, 179, 19 : 270.0, 358.0, 0.0
      'KellyHome' 5, -395, -40 : 0.0, 0.0, 0.0
      'KellyEnd' 0, 218, 43 : 0.0, 0.0, 0.0
```

```
        'KellyVars' 0, 80, 0 : 0.0, 0.0, 0.0
    'ForcepGrab' 1518, 371, -1227 : 0.0, 0.0, 0.0
        'Forcep' 0, 40, 0 : 0.0, 0.0, 270.0
            'ForcepEnd' 0, 0, -401 : 0.0, 0.0, 3.0
            'ForcepFlare' 0, -7, 0 : 0.0, 353.0, 0.0
            'ForceptFlare2' 0, 7, 0 : 0.0, 7.0, 0.0
            'ForcepHome' 31, 2, 0 : 0.0, 0.0, 0.0
        'ForcepVars' 1, 80, 0 : 0.0, 0.0, 0.0
    'ClipApGrab' 1852, 336, -1156 : 0.0, 0.0, 0.0
        'ClipApplierEnd' 0, 32, -550 : 270.0, 89.9, 270.0
        'ClipApplier' 0, 32, -128 : 270.0, 270.0, 0.0
            'ClipShaft' 16, 0, 0 : 90.0, 0.0, 270.0
            'ClipLeftFlare' 80, 16, -2 : 180.0, 0.0, 90.0
            'ClipRightFlare' 80, -16, -2 : 0.0, 0.0, 280.0
            'ClipApHome' -127, 2, -28 : 0.0, 0.0, 270.0
            'ClipAp?' -80, 0, 0 : 0.0, 0.0, 90.0
        'ClipApVars' 1, 80, 0 : 0.0, 0.0, 0.0
    'RAGrab' 2240, 380, -1177 : 0.0, 0.0, 0.0
        'RAClamp' 420, 120, -250 : 0.0, 270.0, 0.0
            'RAFlare' 0, 0, 0 : 180.0, 0.0, 350.0
                'RAEnd' 4, 240, -20 : 270.0, 0.0, 0.0
            'RAEnd2' 4, 240, 20 : 90.0, 0.0, 0.0
            'RAClamphome' -420, -250, -120 : 0.0, 0.0, 0.0
        'RAVars' 0, 80, 0 : 0.0, 0.0, 0.0
    'lampgrab' 1280, -1520, -1789 : 226.8, 66.4, 249.7
        'lamp' 0, 0, 570 : 0.0, 0.0, 90.0
            'LightKnob' -708, 0, -188 : 56.1, 0.0, 75.3
                'Object196' 58, 0, 145 : 0.0, 0.0, 90.1
            'bulb' 0, 0, 0 : 0.0, 180.0, 0.0
    'lampgrab2' -850, 698, -1031 : 122.1, 293.7, 256.1
        'lamp2' 0, 0, 570 : 0.0, 0.0, 90.0
            'LightKnob2' -808, 0, -207 : 61.8, 0.0, 16.9
                'Object200' 58, 0, 145 : 0.0, 0.0, 90.1
            'bulb2' 0, 0, 0 : 0.0, 180.0, 0.0
    'LSloppyTool' 80, 80, 0 : 0.0, 0.0, 0.0
        'LObjCenter' -66, -245, -542 : 276.2, 38.2, 14.1
            'LObjTEnd' 56, -94, -47 : 263.9, 87.4, 0.0
                'LObjTGrab' -1, -1, 578 : 6.4, 359.7, 84.1
        'LVirtToolGrab' -498, -755, -849 : 113.4, 25.4, 47.1
            'LVirtToolEnd' -3, 66, -576 : 105.4, 21.6, 68.0
```

```
0 _light1 1  0.000000 0.000000 0.000000   1.000000 1.000000 1.000000
0.000000 0.000000 0.000000   -0.676514 -0.417236 0.606934   0.000000 90.000000

5 spot 1 bulb  0.000000 0.000000 0.000000   0.000000 0.000000 0.000000
0.000000 0.000000 -1.000000   0.000000 90.000000

5 spot2 1 bulb2  0.000000 0.000000 0.000000   0.000000 0.000000 0.000000
0.000000 0.000000 -1.000000   0.000000 90.000000

6 WestWall 1 textures/pSideWall.rgb  12400.000000 7000.000000 660.000000
0.000000 1.000000 0.000000 -420.000000   0.000000 0.000000 -1.000000 0.000000

6 EastWall 1 textures/sClockWall.rgb  10400.000000 7800.000488 660.000000
0.000000 1.000000 0.000000 -2400.000000   0.000000 0.000000 -1.000000 -
120.000000

6 Floor 1 textures/Floor.rgb  400.000000 400.000000 400.000000   1.000000
0.000000 0.000000 0.000000   0.000000 1.000000 1.000000 0.000000

6 NorthWall 1 textures/pBackWall.rgb  12800.000000 8400.000000 660.000000
0.000000 1.000000 0.000000 0.000000   0.000000 0.000000 -1.000000 240.000000

6 Drape 1 textures/Drape.rgb  1500.000000 1500.000000 1500.000000   1.000000
0.000000 0.000000 0.000000   0.000000 1.000000 1.000000 0.000000

6 FatLayer1 1 textures/sFat.rgb  300.000000 300.000000 300.000000   -0.880000
1.000000 0.580000 0.000000   0.588000 0.000000 0.809000 0.000000

6 HepGastLig 1 textures/HepLig.rgb  400.000000 400.000000 400.000000   -
0.760000 -1.000000 1.000000 0.000000   0.620000 -1.000000 0.000000 0.360000

6 skinR 1 textures/Belly.rgb  640.000000 800.000000 660.000000   -1.000000
0.000000 -1.000000 -105.000000   0.000000 1.000000 0.000000 -300.000000

6 skinL 1 textures/Belly.rgb  1019.999939 980.000061 660.000000   1.000000
0.000000 -1.000000 36.000000   0.000000 1.000000 0.000000 1620.000000

6 Stomach 1 textures/Stomach.rgb  50.000000 50.000000 50.000000   -0.300000 -
0.580000 0.380000 -7.200000   0.000000 1.000000 0.500000 -30.000000
```

```
6 Duct 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000 0.000000
0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 CommonDuct 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000
0.000000 0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 DCut 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000 0.000000
0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 DCutB 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000 0.000000
0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 DCutA 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000 0.000000
0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 Whole 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000 0.000000
0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 DWholeFlat 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000
0.000000 0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 DuctAnchor 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000
0.000000 0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 DuctPull 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000
0.000000 0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 DWholeBent 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000
0.000000 0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 DClipGrab2 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000
0.000000 0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 CysticClip2 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000
0.000000 0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

6 CysticClip1 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000
0 000000 0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000
```

```
6 Pancreas 1 textures/Pancreas.rgb  3.000000 3.000000 3.000000   0.283000
0.262000 0.922000 1.400000   -0.021000 0.680000 0.733000 1.200000

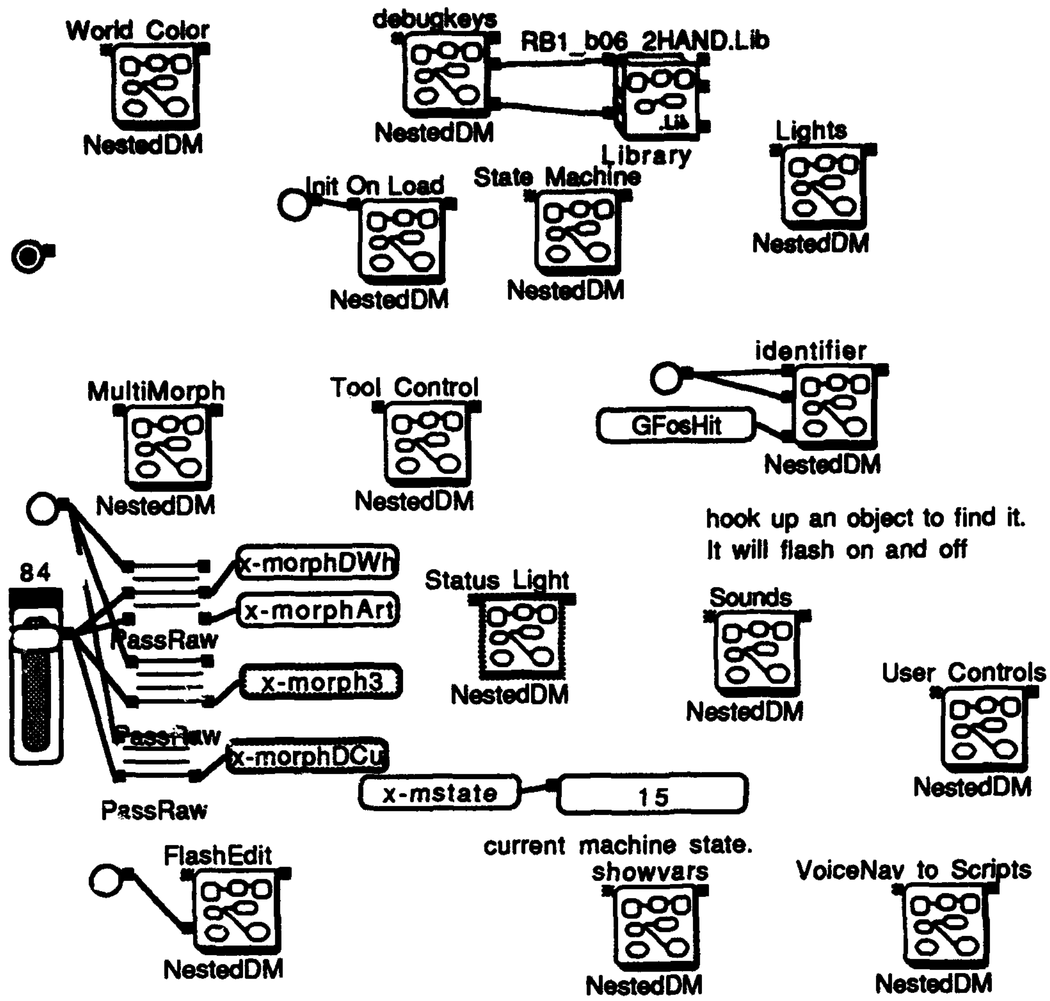
6 LiverRotate 0 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000
0.000000 0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

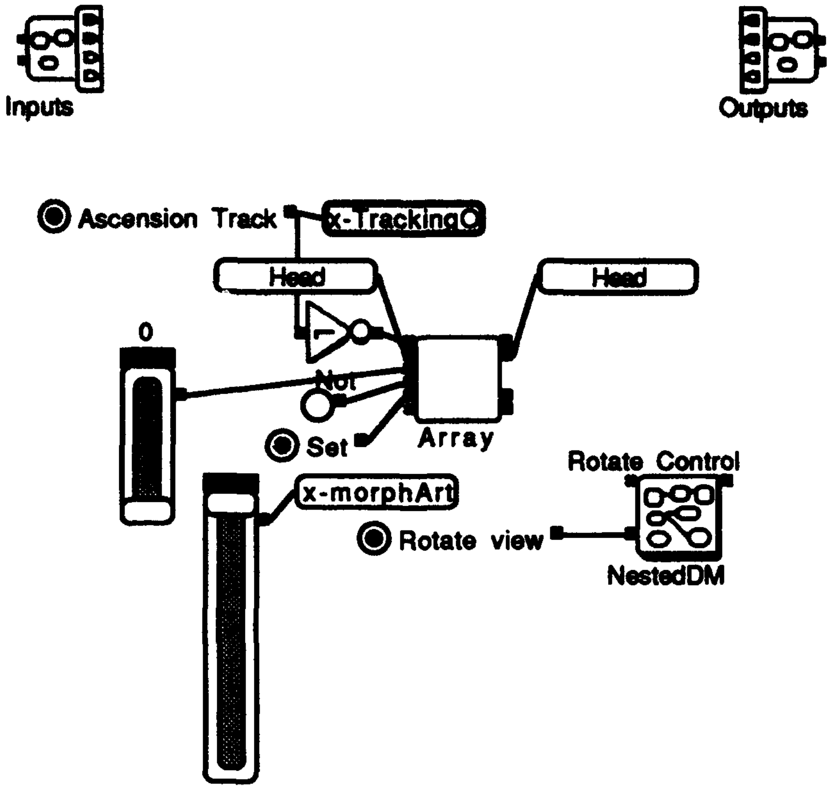
6 gallbladder 1 textures/GB.rgb  150.000000 150.000000 150.000000   1.000000
0.000000 0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

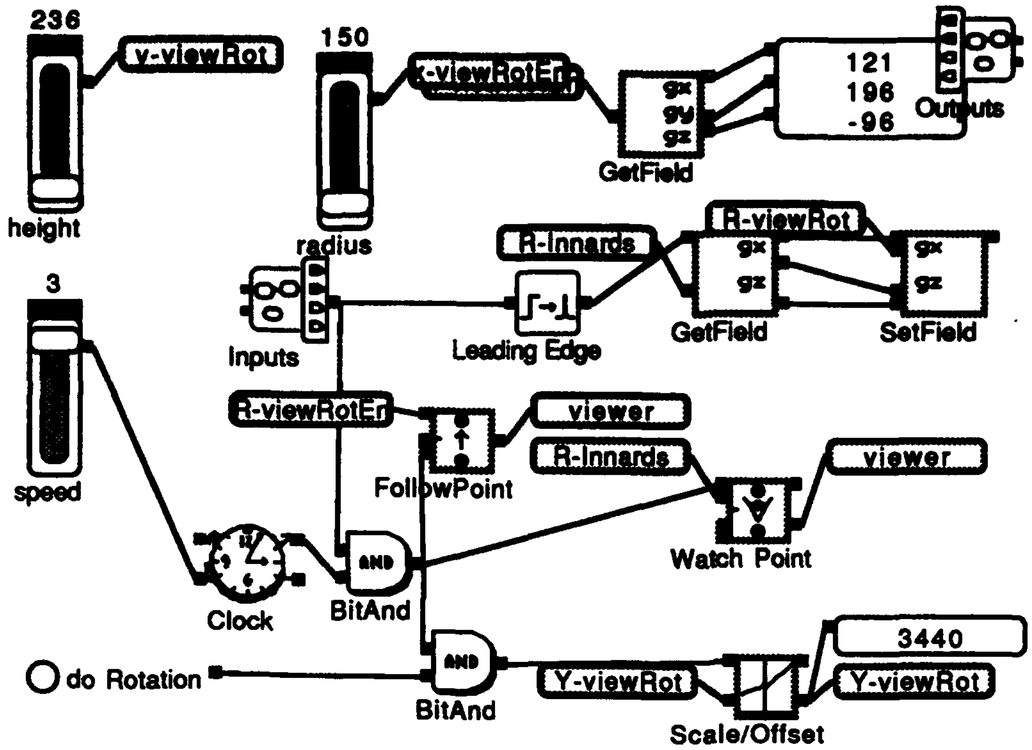
6 BallBladder 1 textures/GB.rgb  50.000000 50.000000 50.000000   1.000000
0.000000 0.620000 -3.600000   -0.120000 0.980000 -0.060000 34.000000

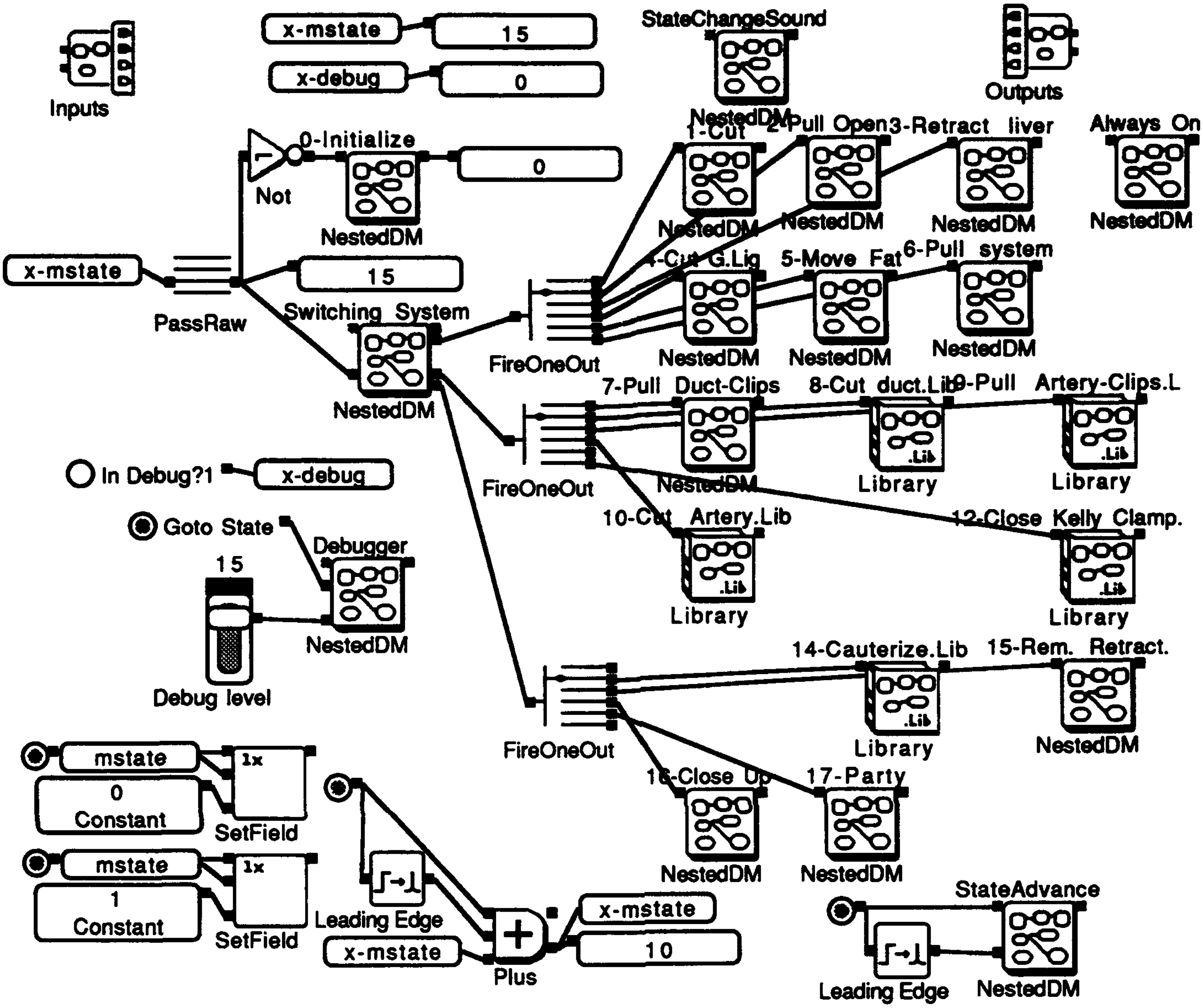
6 Liver 1 textures/Liver.rgb  75.000000 75.000000 75.000000   0.951000
0.149000 -0.271000 -2.400000   0.588000 0.000000 0.809000 0.000000

8 1.000000 0.000000 0.000000
```


World Color
NestedDM
debugkeys
NestedDM
RB1_b06_2HAND.Lib
Library
Init On Load
NestedDM
State Machine
NestedDM
Lights
NestedDM
MultiMorph
NestedDM
Tool Control
NestedDM
identifier
GFosHit
NestedDM
hook up an object to find it.
It will flash on and off
84
x-morphDWh
x-morphArt
PassRaw
x-morph3
PassRaw
x-morphDCu
PassRaw
Status Light
NestedDM
Sounds
NestedDM
User Controls
NestedDM
x-mstate
15
current machine state.
FlashEdit
NestedDM
showvars
NestedDM
VoiceNav to Scripts
NestedDM

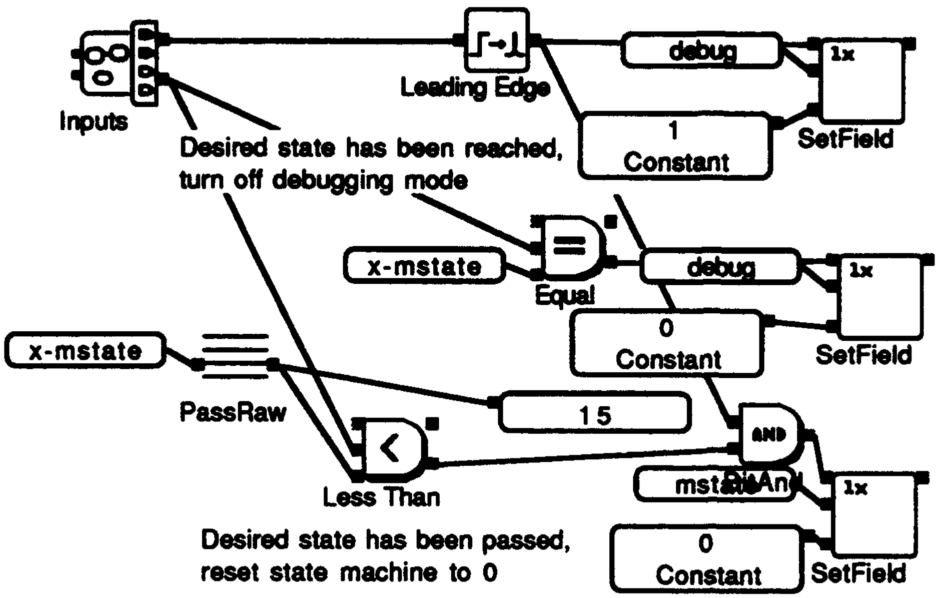

Inputs
Outputs
Ascension Track
x-TrackingO
Head
Head
0
Not
Array
Set
Rotate Control
x-morphArt
Rotate view
NestedDM

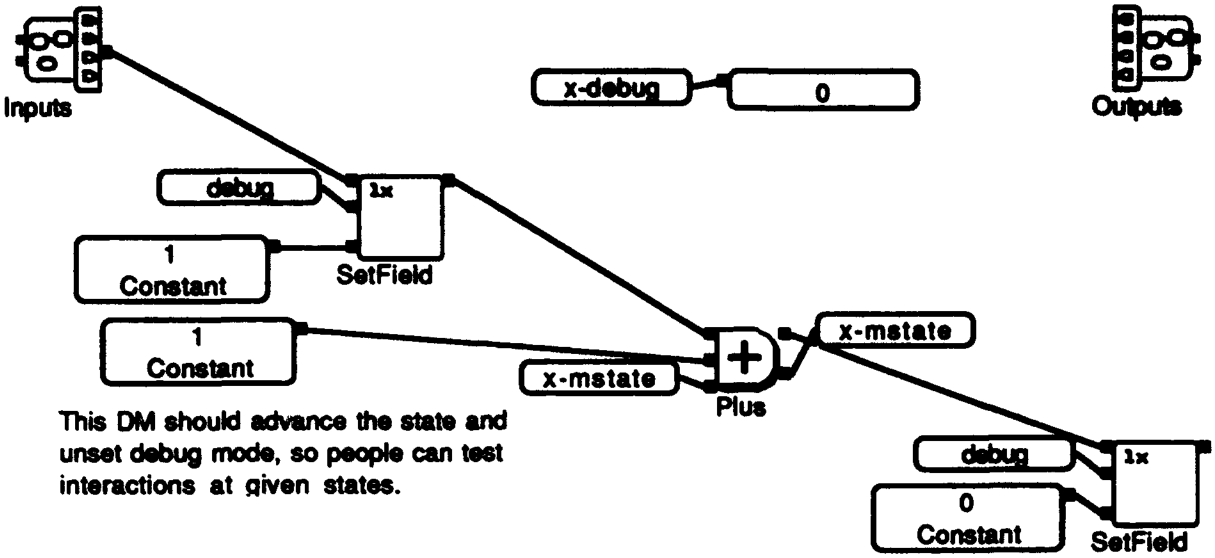

236
y-viewRot
height
150
x-viewRotEn
radius
gx
gy
gz
GetField
121
196
-96
Outputs
3
speed
Inputs
R-Innards
Leading Edge
R-viewRot
gx
gz
GetField
gx
gz
SetField
R-viewRotEn
viewer
FollowPoint
R-Innards
viewer
Watch Point
Clock
BitAnd
do Rotation
BitAnd
3440
Y-viewRot
Y-viewRot
Scale/Offset

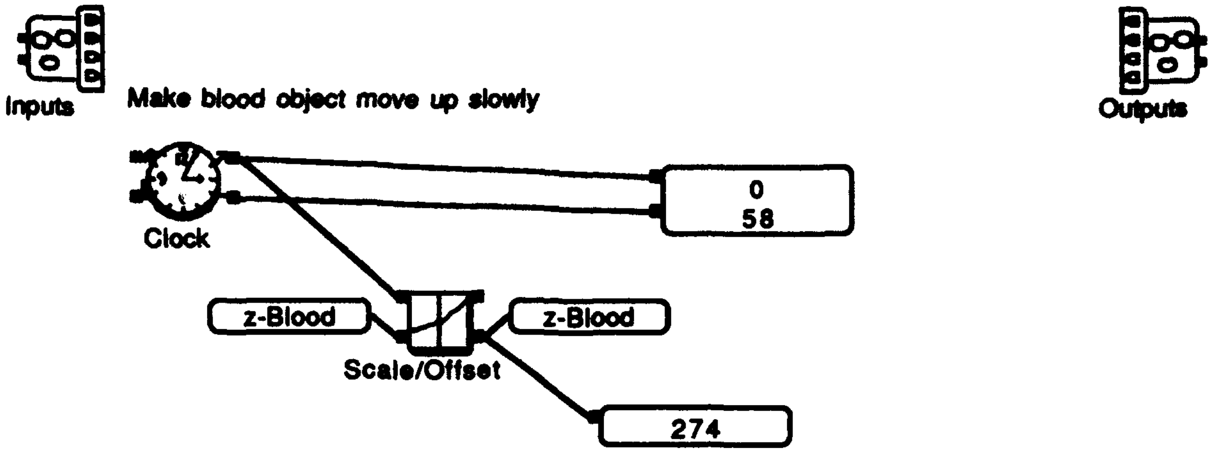


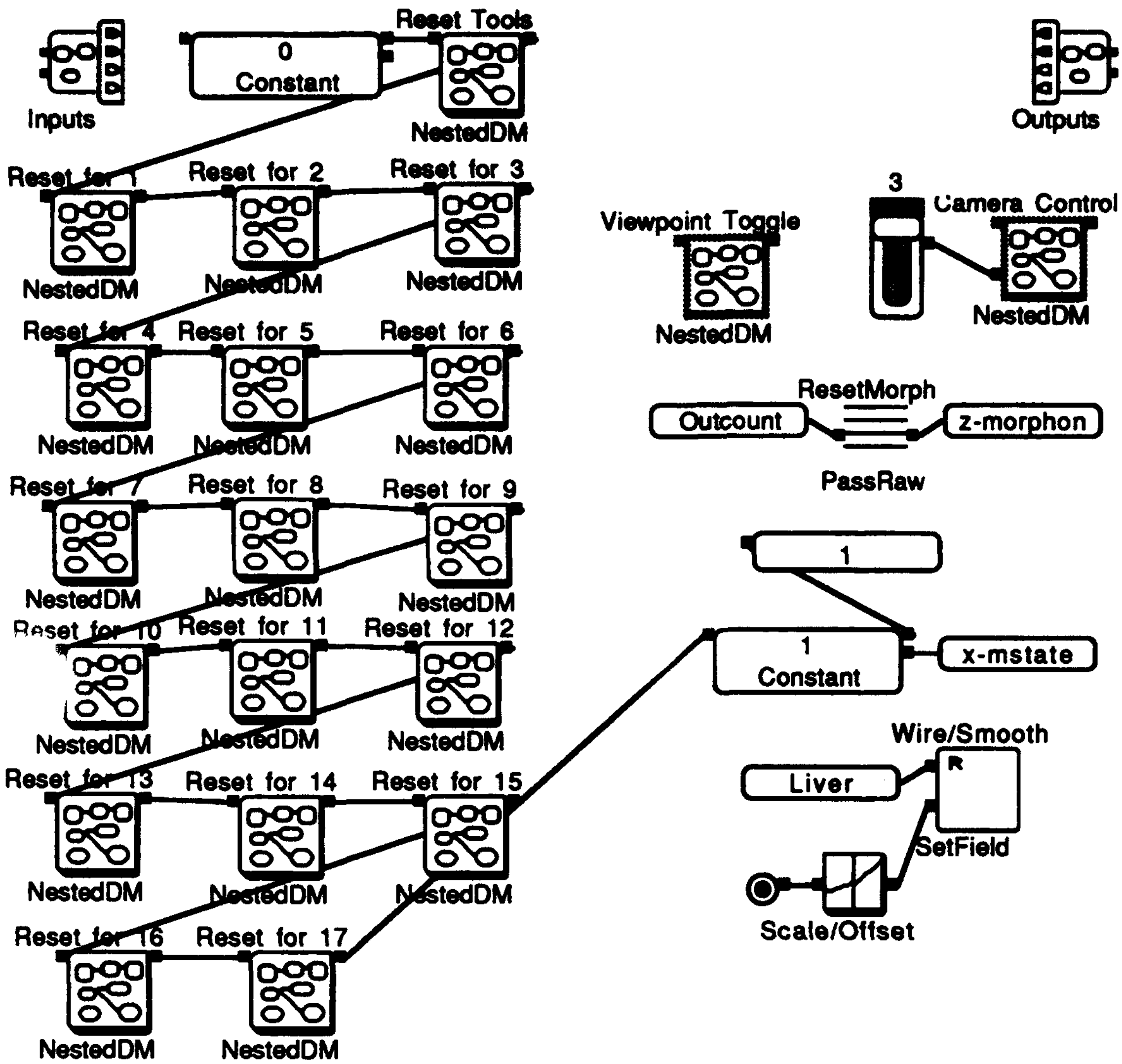
Inputs
x-mstate
15
x-debug
0
StateChangeSound
NestedDM
Outputs
Not
0-Initialize
NestedDM
0
1-Cut
2-Pull Open
3-Retract liver
Always On
NestedDM
NestedDM
NestedDM
NestedDM
x-mstate
PassRaw
15
Switching System
NestedDM
4-Cut G.Lig
5-Move Fat
6-Pull system
NestedDM
NestedDM
NestedDM
FireOneOut
7-Pull Duct-Clips
8-Cut duct.Lib
9-Pull Artery-Clips.L
NestedDM
Library
Library
FireOneOut
In Debug?1
x-debug
Goto State
Debugger
15
NestedDM
Debug level
10-Cut Artery.Lib
Library
12-Close Kelly Clamp.
Library
14-Cauterize.Lib
15-Rem. Retract.
Library
NestedDM
FireOneOut
16-Close Up
17-Party
NestedDM
NestedDM
mstate
0
Constant
SetField
mstate
1
Constant
SetField
Leading Edge
x-mstate
Plus
x-mstate
10
StateAdvance
Leading Edge
NestedDM

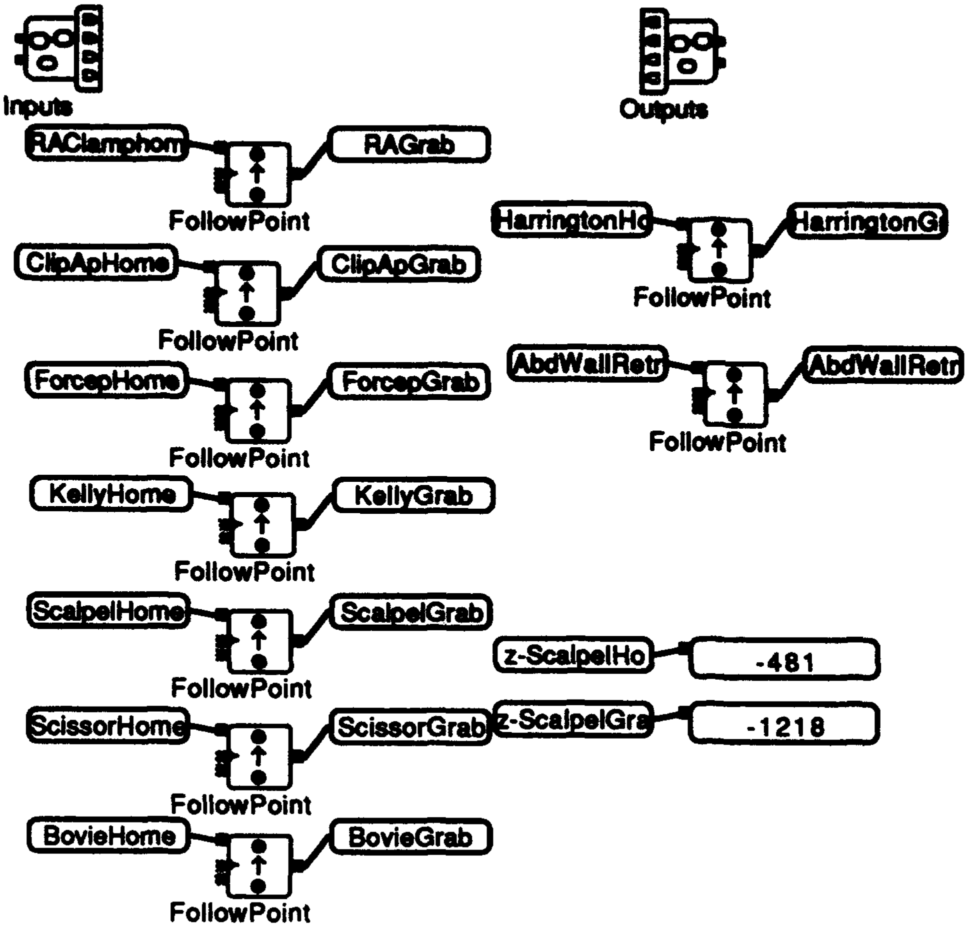
Debugger tool
Set slider to desired state,
Push button, and DM will advance
state machine to that state
automatically

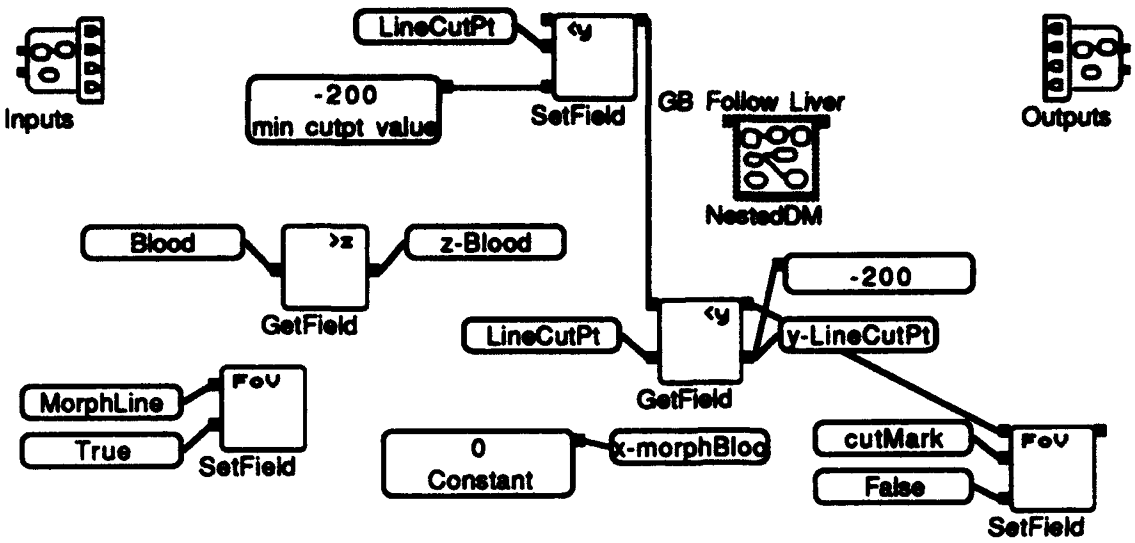


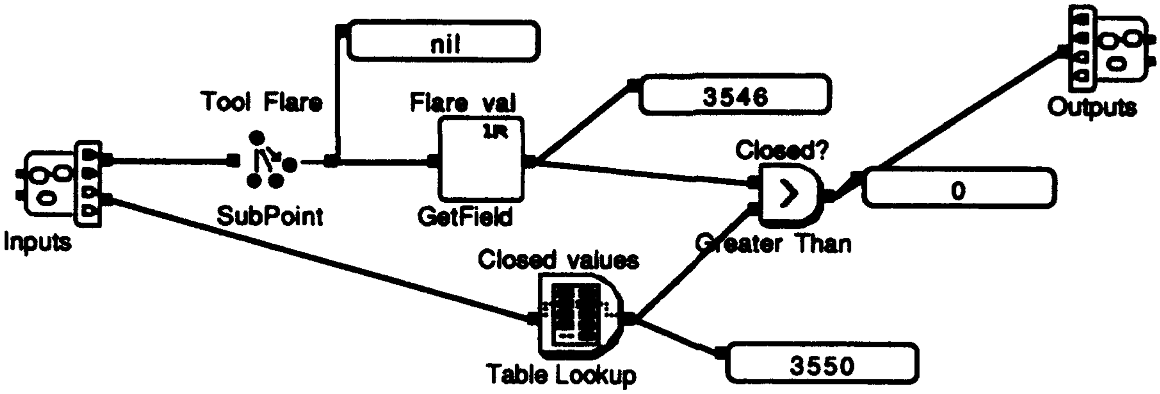

Inputs
x-debug
0
Outputs
debug
1x
1
Constant
SetField
1
Constant
x-mstate
x-mstate
Plus
This DM should advance the state and unset debug mode, so people can test interactions at given states.
debug
1x
0
Constant
SetField

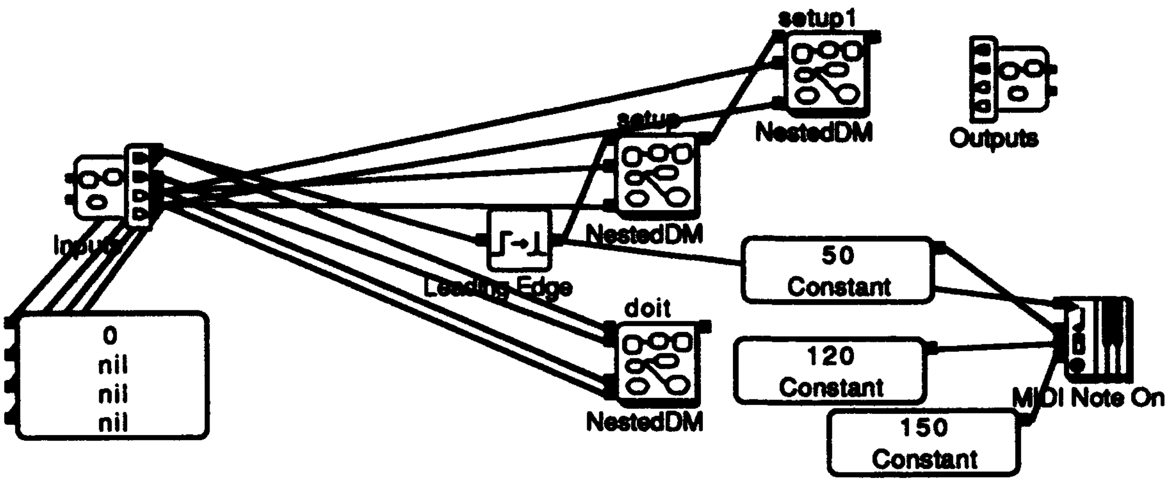

Inputs
Make blood object move up slowly
Outputs
Clock
0
58
z-Blood
z-Blood
Scale/Offset
274

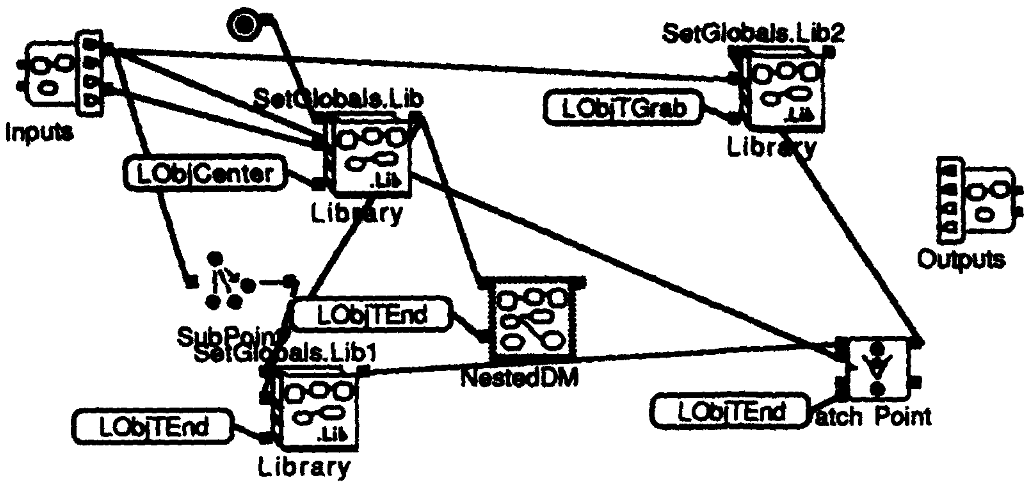

Inputs
0
Constant
Reset Tools
NestedDM
Outputs
Reset for 1
Reset for 2
Reset for 3
NestedDM
NestedDM
NestedDM
Viewpoint Toggle
NestedDM
3
Camera Control
NestedDM
Reset for 4
Reset for 5
Reset for 6
NestedDM
NestedDM
NestedDM
ResetMorph
Outcount
z-morphon
PassRaw
Reset for 7
Reset for 8
Reset for 9
NestedDM
NestedDM
NestedDM
1
1
Constant
x-mstate
Reset for 10
Reset for 11
Reset for 12
NestedDM
NestedDM
NestedDM
Wire/Smooth
Liver
R
SetField
Reset for 13
Reset for 14
Reset for 15
NestedDM
NestedDM
NestedDM
Scale/Offset
Reset for 16
Reset for 17
NestedDM
NestedDM


Inputs
Outputs
RAClamphom
RAGrab
FollowPoint
HarringtonHo
HarringtonGr
FollowPoint
ClipApHome
ClipApGrab
FollowPoint
ForcepHome
ForcepGrab
FollowPoint
AbdWallRetr
AbdWallRetr
FollowPoint
KellyHome
KellyGrab
FollowPoint
ScalpelHome
ScalpelGrab
FollowPoint
z-ScalpelHo
-481
ScissorHome
ScissorGrab
FollowPoint
z-ScalpelGra
-1218
BovieHome
BovieGrab
FollowPoint

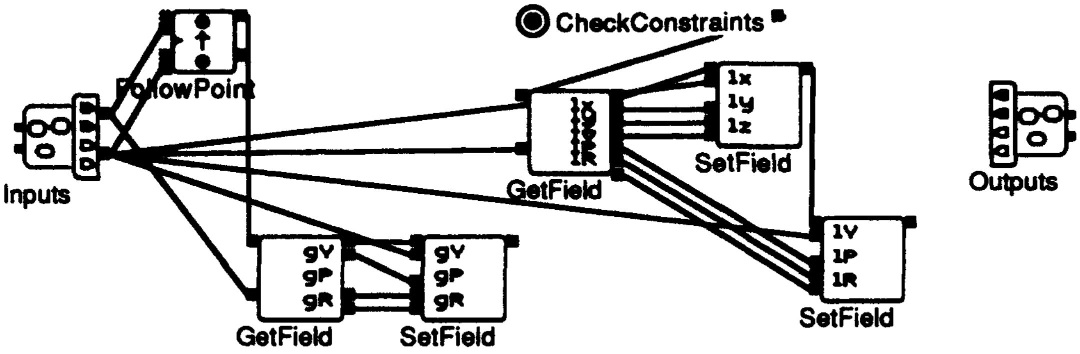

LineCutPt
Inputs
-200
min cutpt value
SetField
GB Follow Liver
NestedDM
Outputs
Blood
z-Blood
GetField
-200
LineCutPt
y-LineCutPt
GetField
MorphLine
True
SetField
0
Constant
x-morphBloc
cutMark
False
SetField


nil
Tool Flare
Flare val
3546
Closed?
Outputs
Inputs
SubPoint
GetField
0
Greater Than
Closed values
Table Lookup
3550

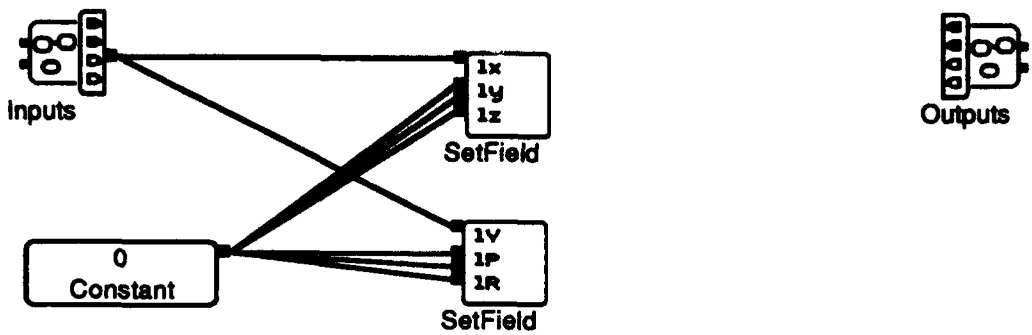

setup1
NestedDM
Outputs
setup
NestedDM
Input
Leading Edge
50
Constant
doit
0
nil
nil
nil
120
Constant
MIDI Note On
NestedDM
150
Constant

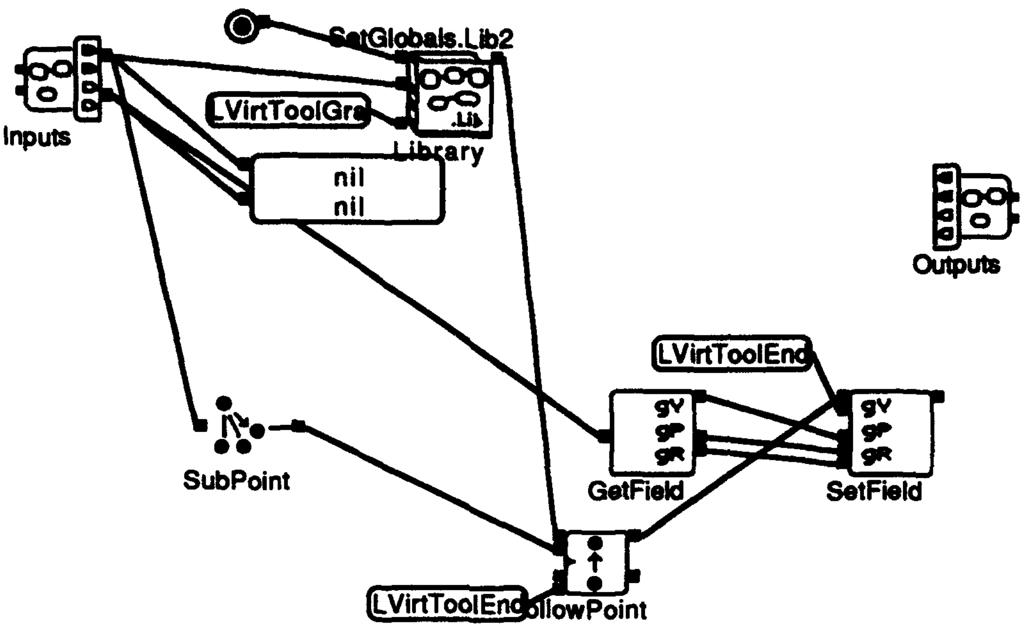


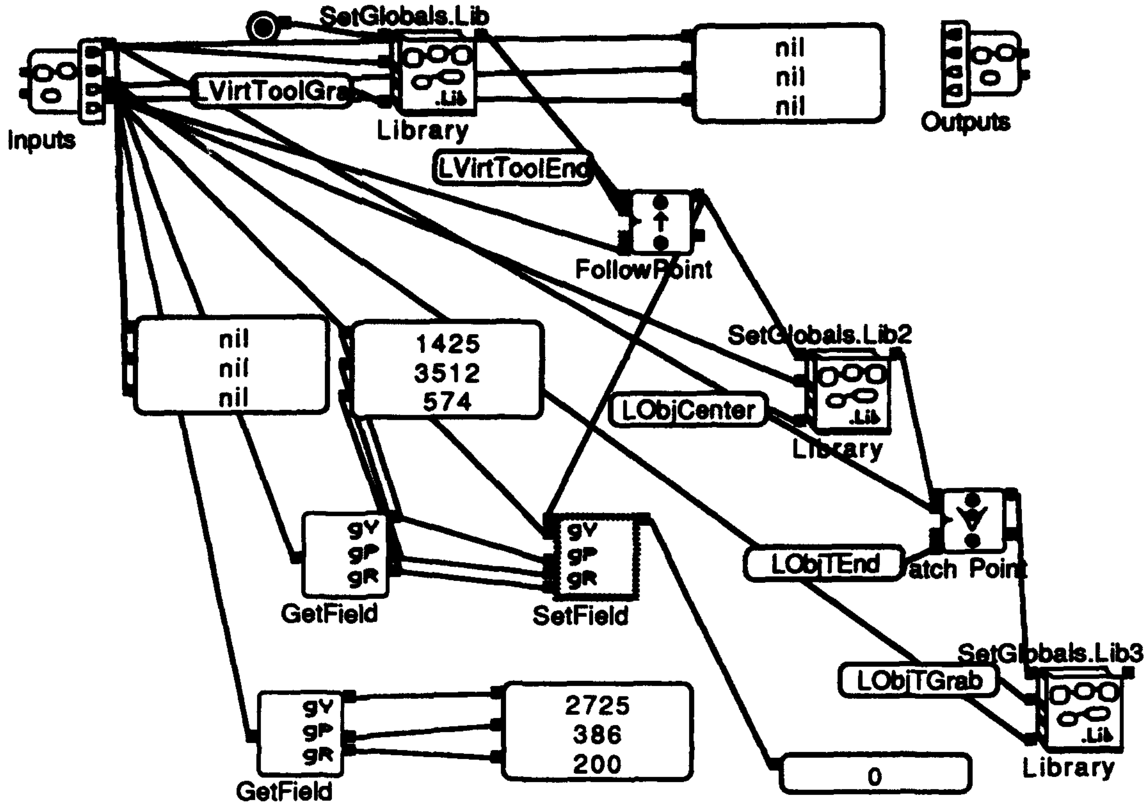
Inputs
SetGlobals.Lib
LObjCenter
Library
SetGlobals.Lib2
LObjTGrab
Library
Outputs
SubPoint
SetGlobals.Lib1
LObjTEnd
NestedDM
LObjTEnd
Library
LObjTEnd
atch Point

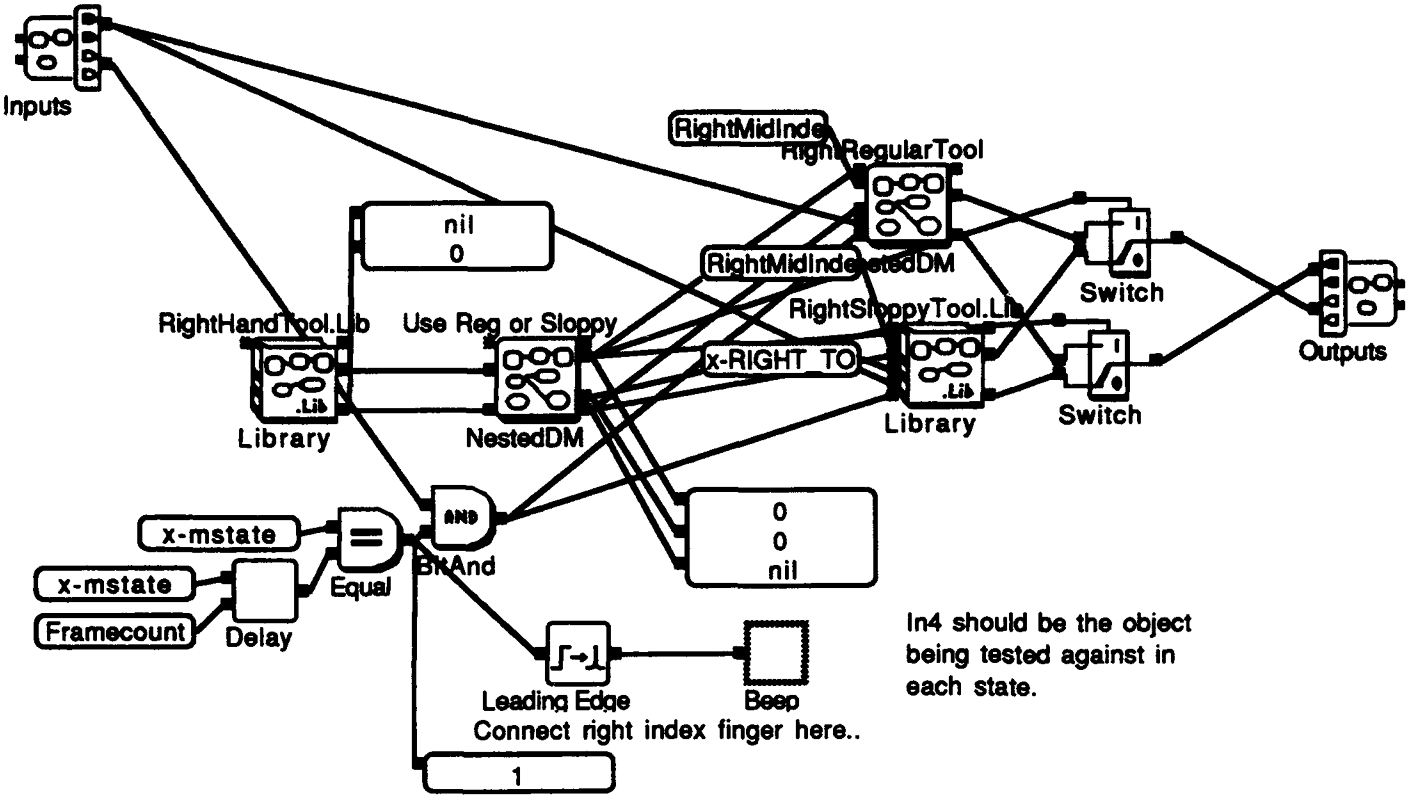


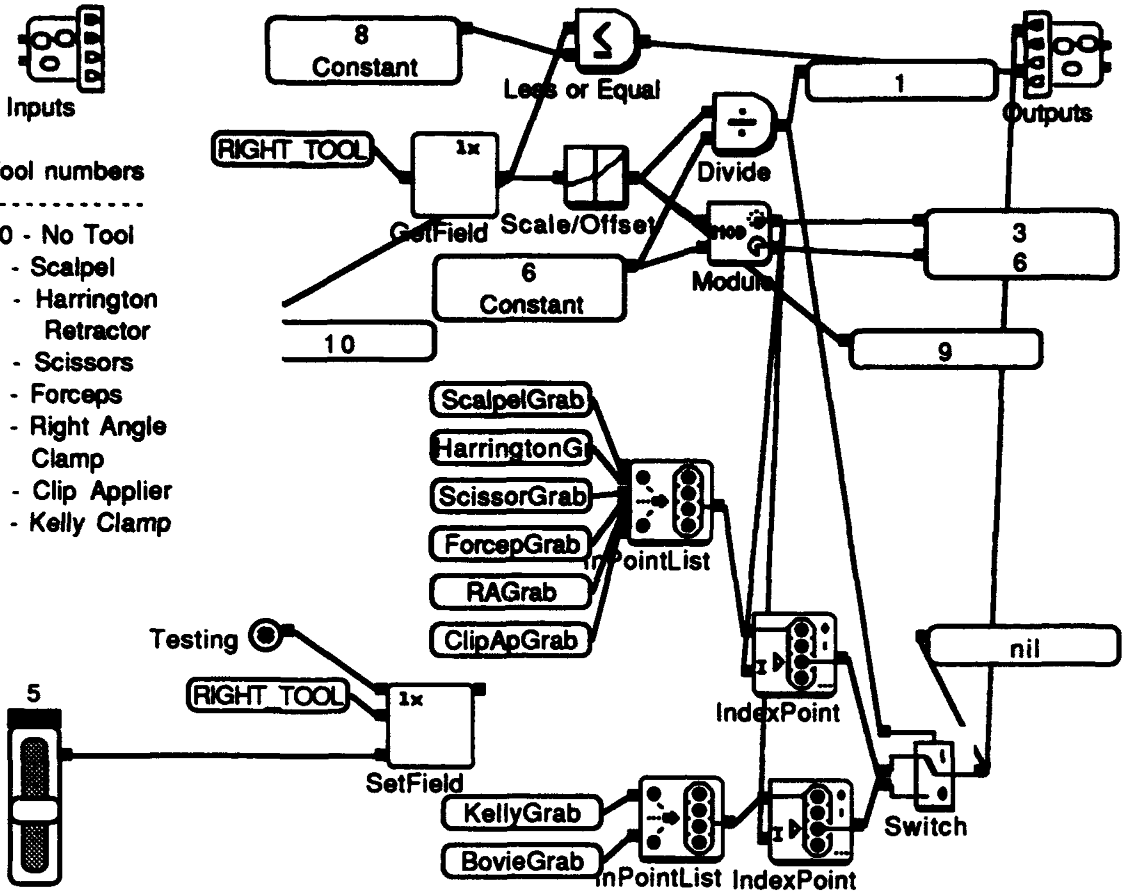
CLB - 4/23/94 - I replaced the global x,y,z setfield
with a followpt because it is more accurate.
I also added the local getfield -> setfield because
global setfield doesn't check for constraints.


Inputs
Outputs
1x
1y
1z
SetField
0
Constant
1V
1P
1R
SetField


SetGlobals.Lib2
Inputs
LVirtToolGra
Library
.Lib
nil
nil
Outputs
LVirtToolEnd
gV
gP
gR
GetField
gV
gP
gR
SetField
SubPoint
LVirtToolEnd
ollowPoint


SetGlobals.Lib
nil
nil
nil
Outputs
LVirtToolGra
Library
Inputs
LVirtToolEnd
FollowPoint
SetGlobals.Lib2
nil
nil
nil
1425
3512
574
LObjCenter
Library
gV
gP
gR
gV
gP
gR
LObjTEnd
atch Point
GetField
SetField
SetGlobals.Lib3
LObjTGrab
gV
gP
gR
2725
386
200
0
Library
GetField

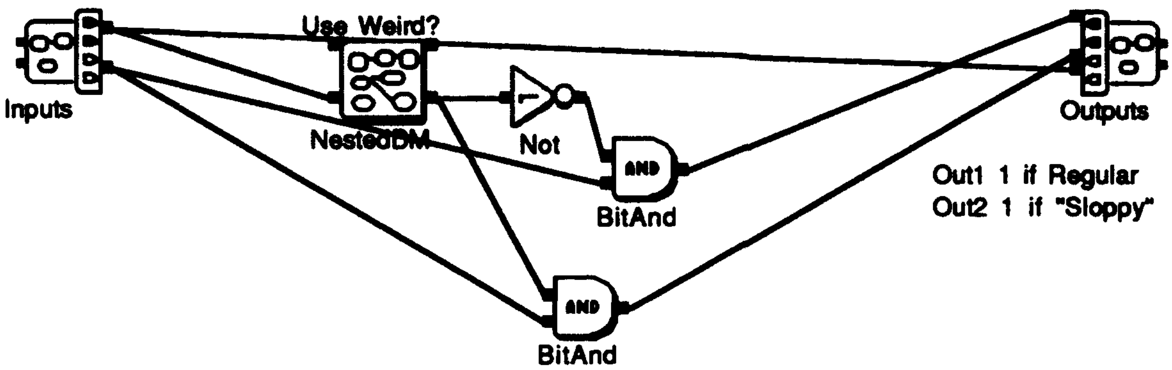

Inputs
RightMidInde
RightRegularTool
nil
0
RightMidInde
NestedDM
Switch
RightHandTool.Lib
Use Reg or Sloppy
RightSloppyTool.Lib
x-RIGHT_TO
Outputs
Library
NestedDM
Library
Switch
0
0
nil
x-mstate
AND
BitAnd
x-mstate
Equal
Framecount
Delay
In4 should be the object
being tested against in
each state.
Leading Edge
Beep
Connect right index finger here..
1

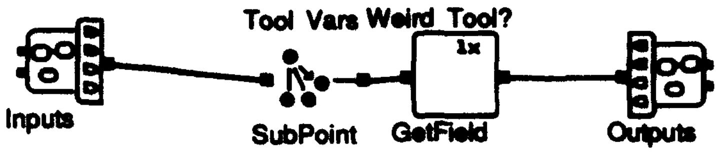


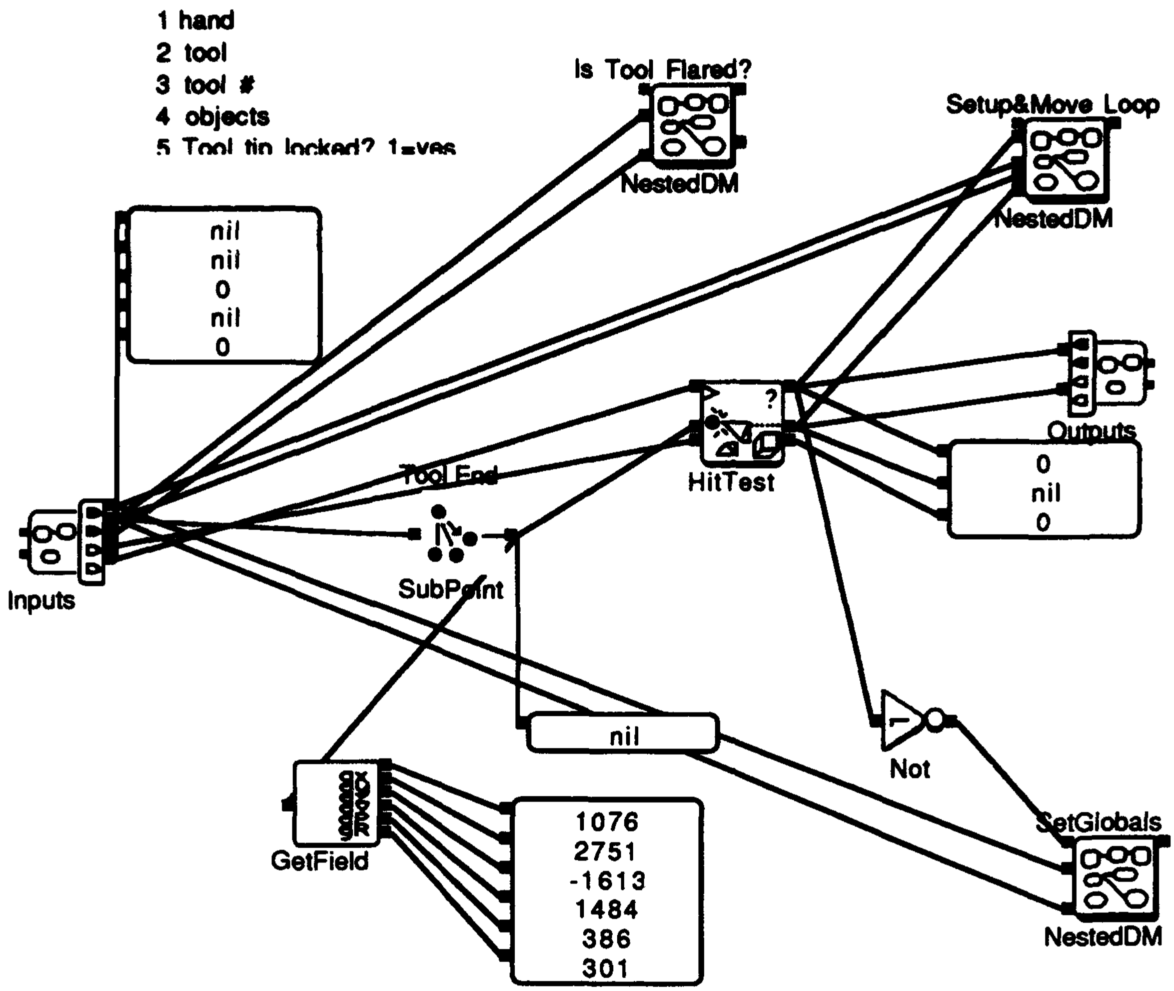
Tool numbers
- - - - - - - - - - - -
10 - No Tool
1 - Scalpel
2 - Harrington Retractor
3 - Scissors
4 - Forceps
5 - Right Angle Clamp
6 - Clip Applier
7 - Kelly Clamp

The point TOOL uses it's local x and y values for:
x - Tool number in left hand
y - Tool number in right hand

›ol currently in right hand.
a tool in the right hand?


Use Weird?
Inputs
NestedDM
Not
BitAnd
BitAnd
Outputs
Out1 1 if Regular
Out2 1 if "Sloppy"


Tool Vars Weird Tool?
1x
Inputs
SubPoint
GetField
Outputs

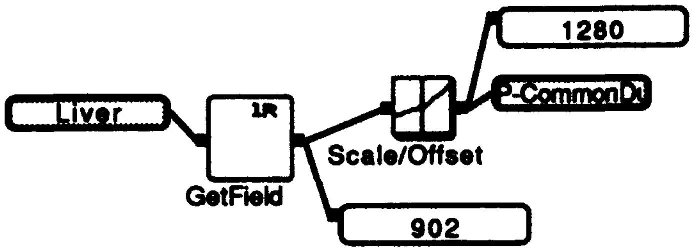


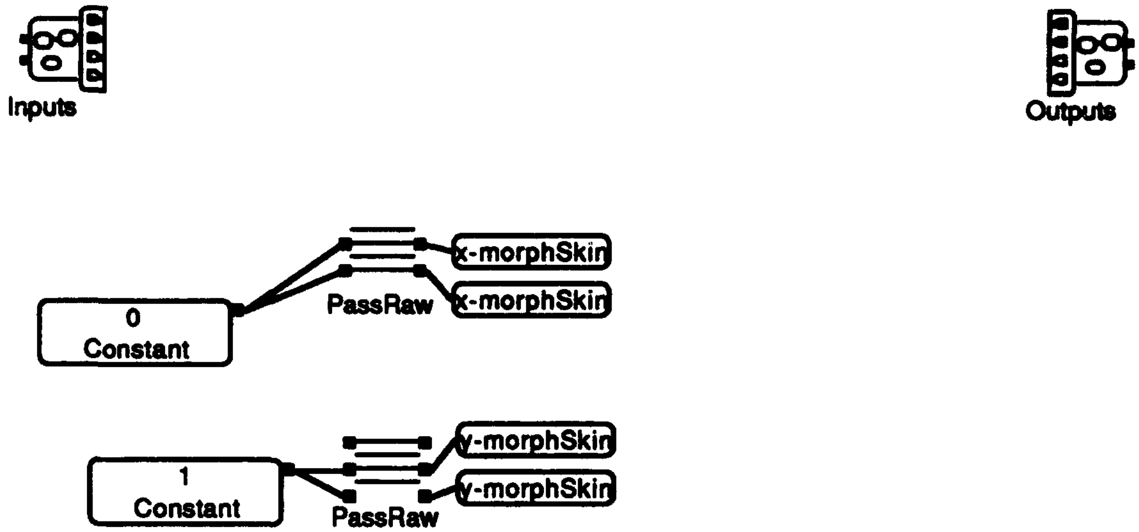
1 hand
2 tool
3 tool #
4 objects
5 Tool tip locked? 1=yes
Is Tool Flared?
NestedDM
Setup&Move Loop
NestedDM
nil
nil
0
nil
0
Outputs
HitTest
0
nil
0
Tool End
SubPoint
Inputs
nil
Not
GetField
SetGlobals
NestedDM
1076
2751
-1613
1484
386
301

Inputs

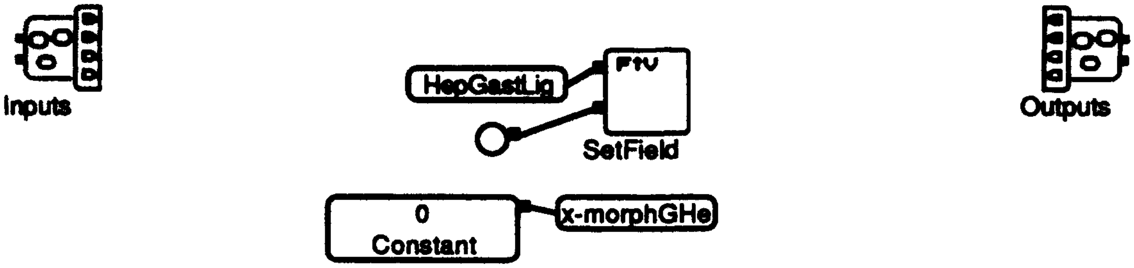
The motion of the GallBladder is driven off of the Liver. The liver rotates between 0 and 750, while the CommonDuct (parent of GallBladder) needs to go from -54 to 1055. So the value coming from R-Liver is multiplied by 1.4786 and 54 is subtracted

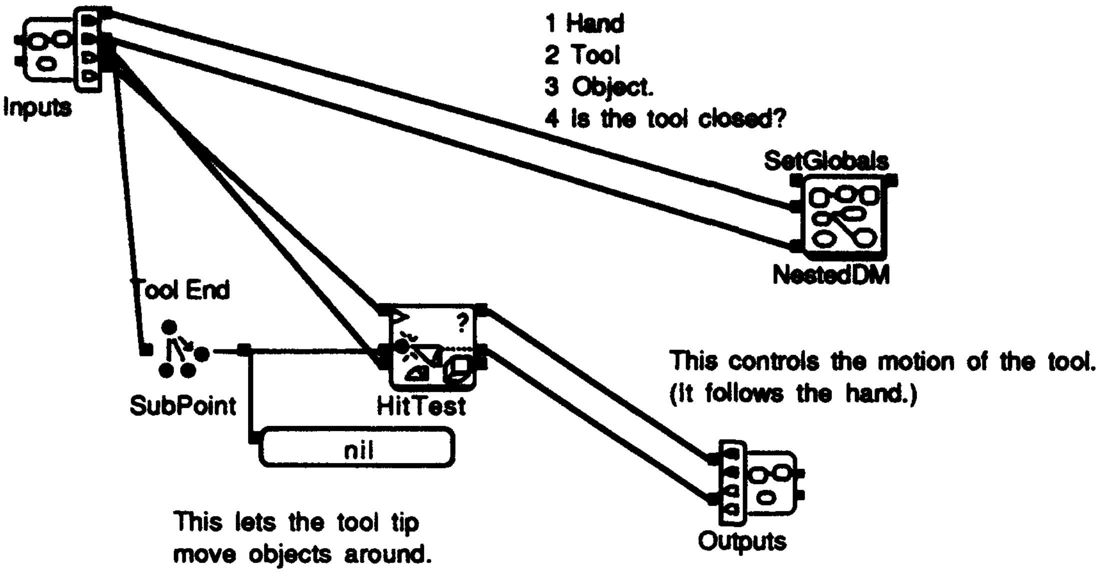
Outputs

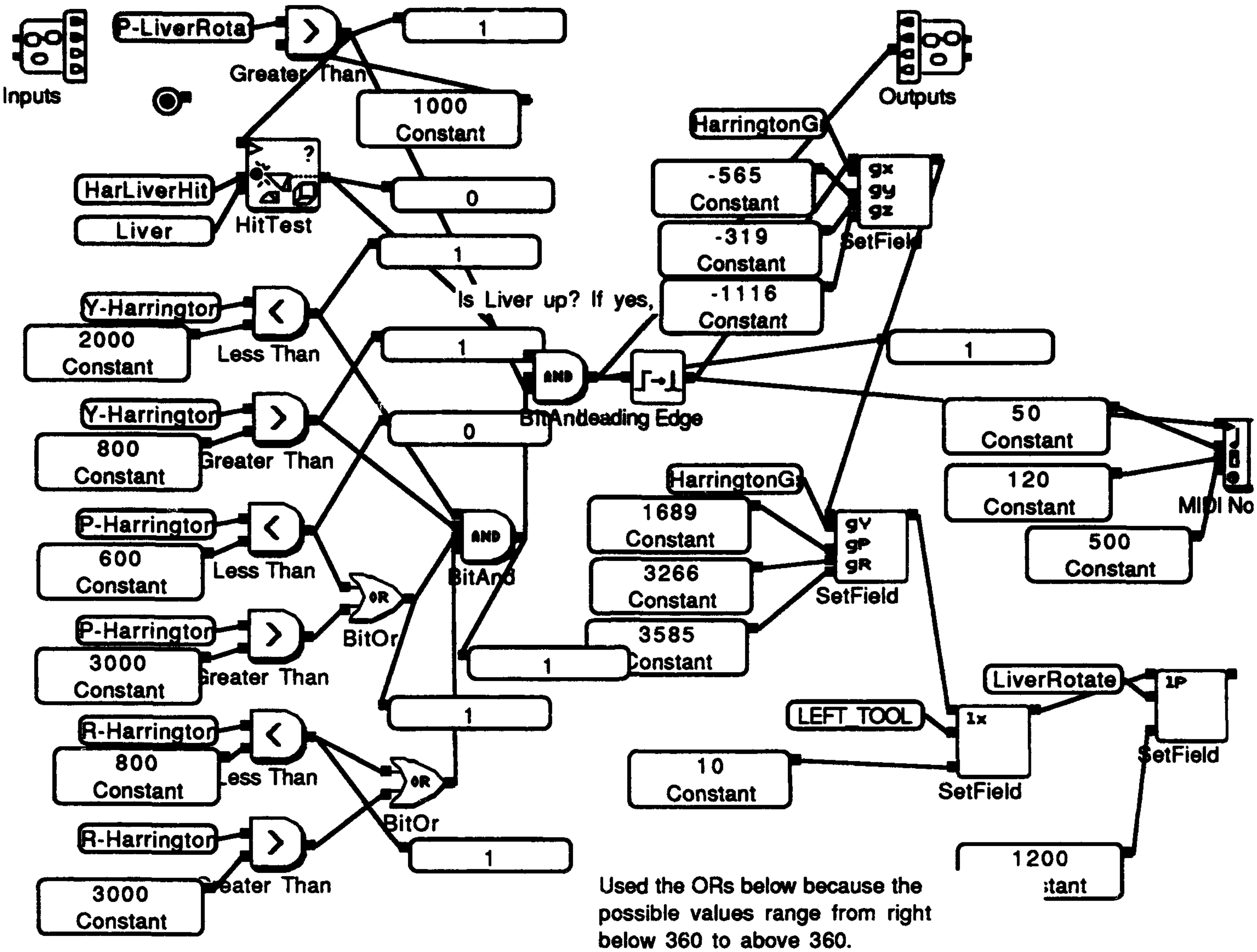



Inputs
Outputs
0
Constant
PassRaw
x-morphSkin
x-morphSkin
1
Constant
PassRaw
y-morphSkin
y-morphSkin

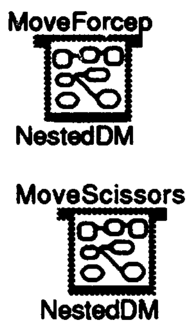

Inputs
Outputs
290
Flipped Down
P-LiverRota


Inputs
HepGastLig
SetField
0
Constant
x-morphGHe
Outputs


1 Hand
2 Tool
3 Object.
4 Is the tool closed?
Inputs
SetGlobals
NestedDM
Tool End
SubPoint
HitTest
?
nil
This controls the motion of the tool.
(It follows the hand.)
This lets the tool tip
move objects around.
Outputs

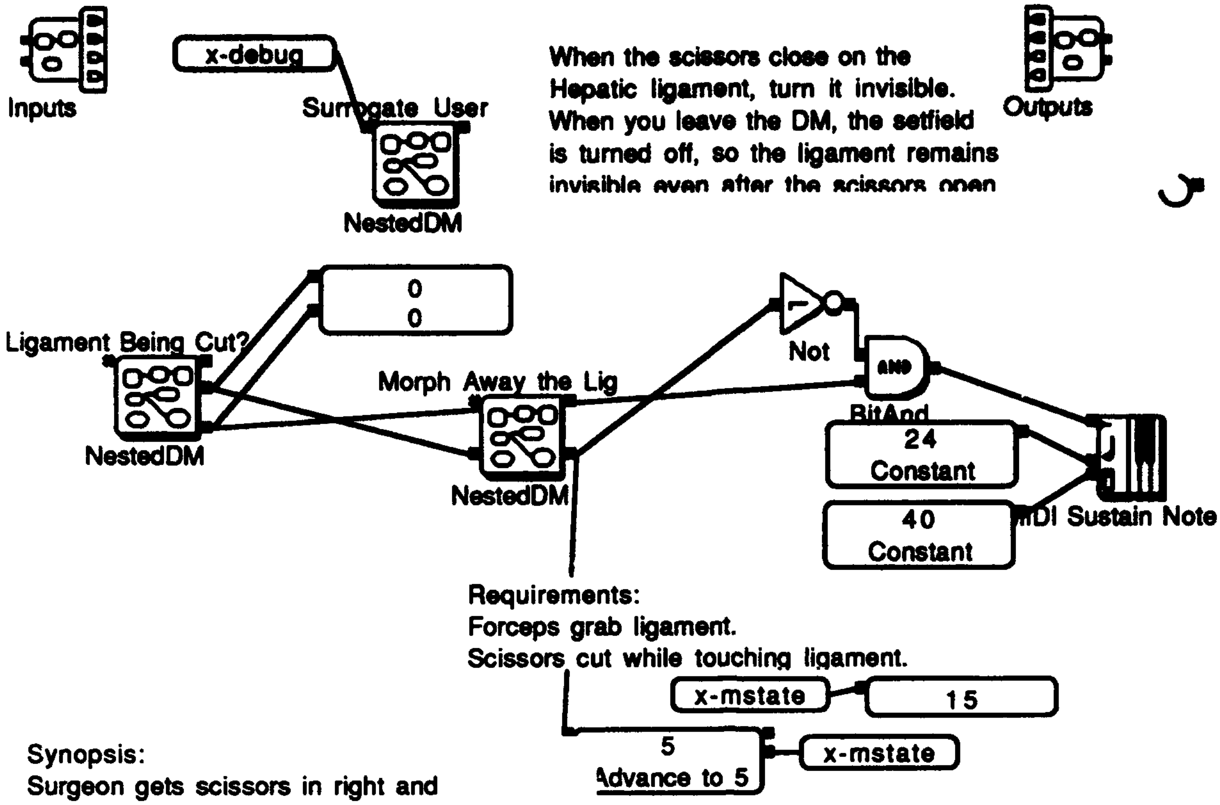


Inputs
P-LiverRota
Greater Than
1
1000
Constant
Outputs
HarringtonG
-565
Constant
-319
Constant
-1116
Constant
gx
gy
gz
SetField
HarLiverHit
Liver
HitTest
0
1
Is Liver up? If yes,
Y-Harrington
2000
Constant
Less Than
1
BitAnd
Leading Edge
1
50
Constant
120
Constant
500
Constant
MIDI No
Y-Harrington
800
Constant
Greater Than
0
HarringtonG
1689
Constant
3266
Constant
3585
Constant
gV
gP
gR
SetField
P-Harrington
600
Constant
Less Than
BitOr
BitAnd
P-Harrington
3000
Constant
Greater Than
1
LiverRotate
1P
SetField
LEFT TOOL
1x
10
Constant
SetField
R-Harrington
800
Constant
Less Than
BitOr
1
R-Harrington
3000
Constant
Greater Than
1200
Constant
Used the ORs below because the possible values range from right below 360 to above 360.



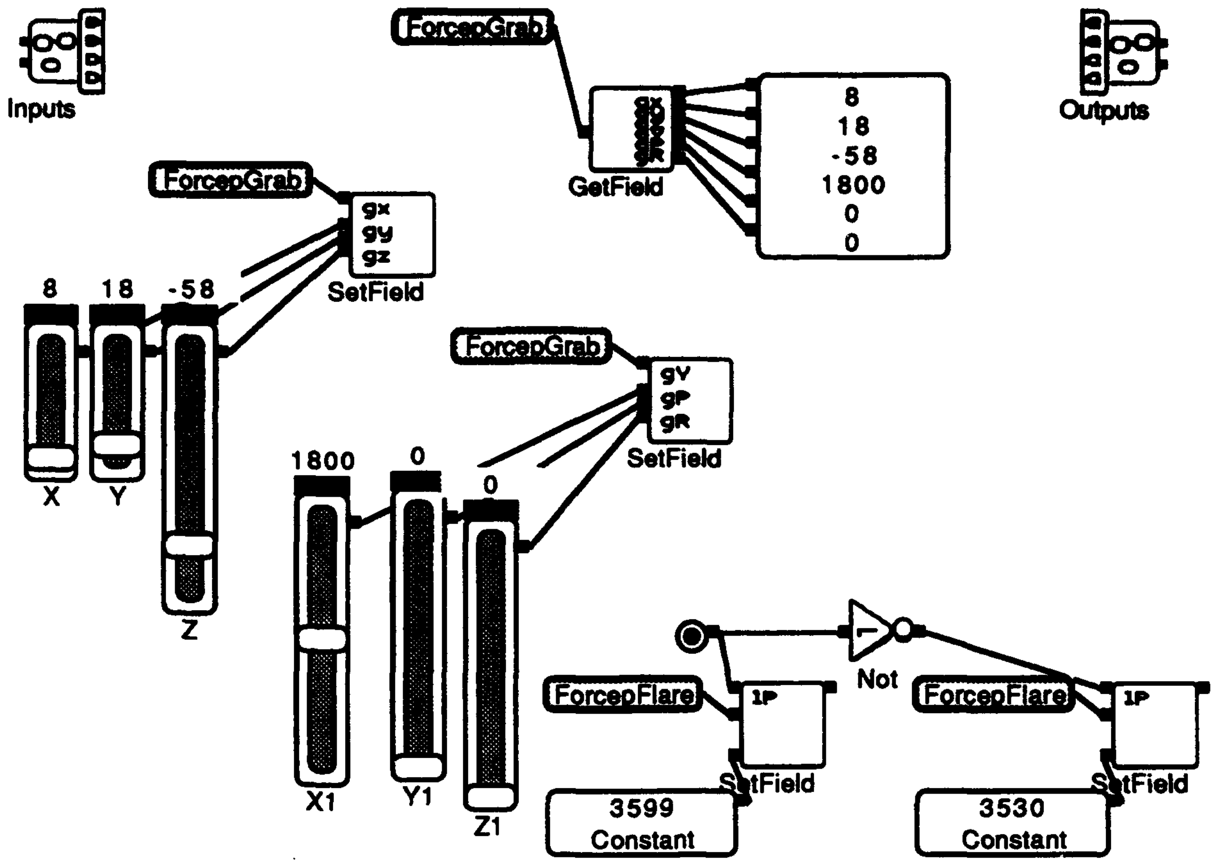
These are the wrong philosophy. Instead of animating changes to the model, we are just making changes to the tree to make sure the model is robust enough

When the scissors close on the Hepatic ligament, turn it invisible. When you leave the DM, the setfield is turned off, so the ligament remains invisible even after the scissors open

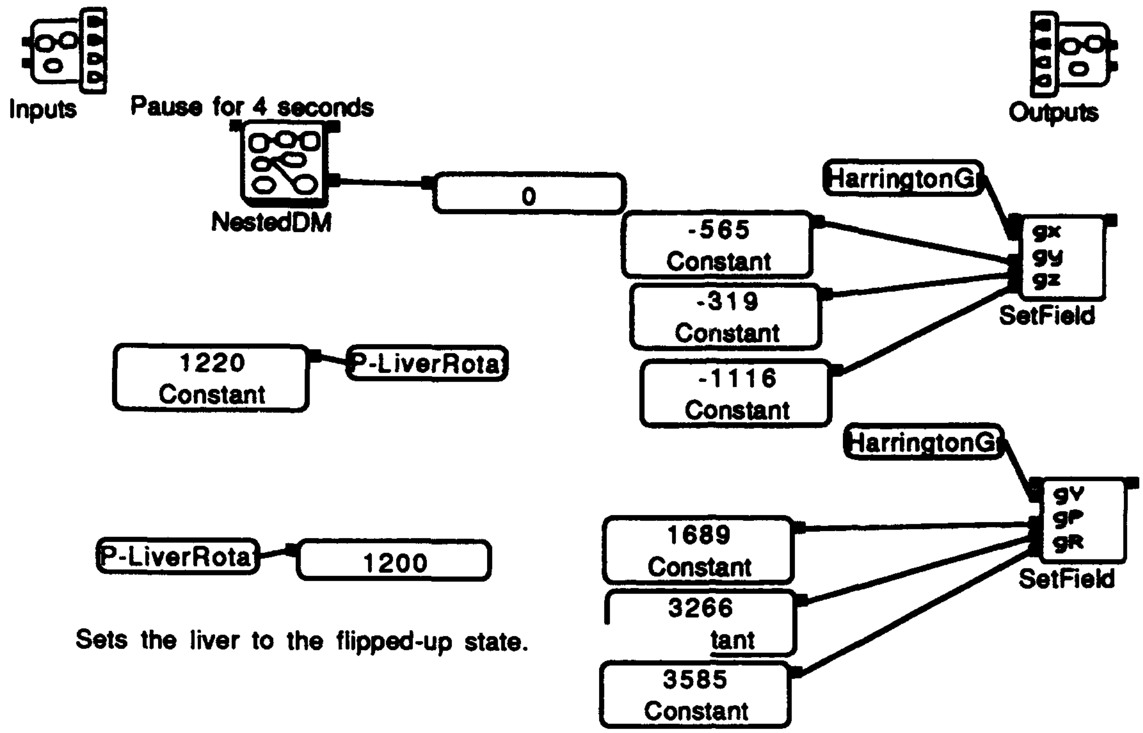


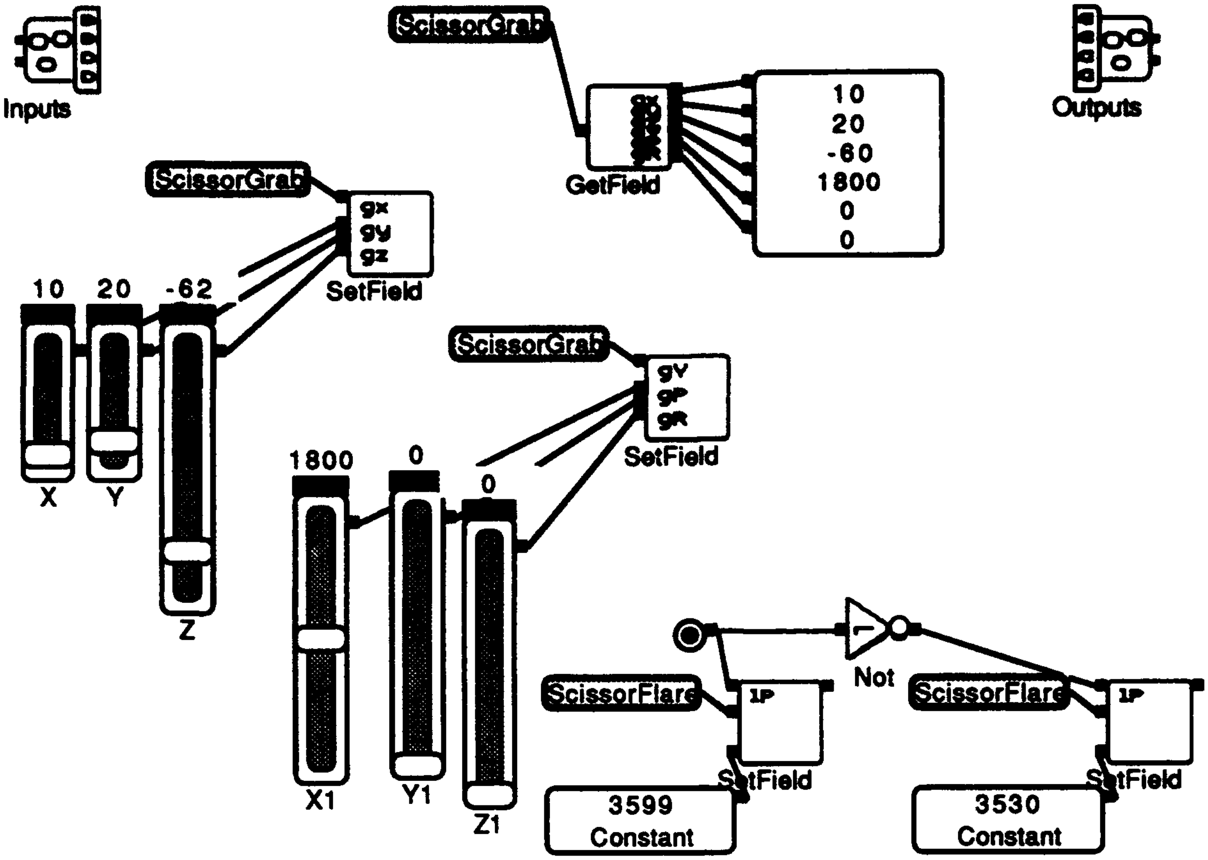
Requirements:
Forceps grab ligament.
Scissors cut while touching ligament.

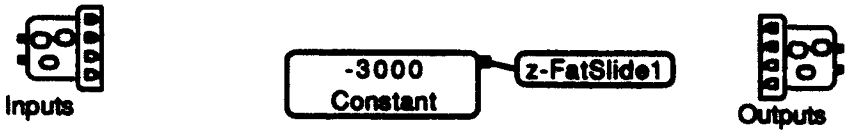
Synopsis:
Surgeon gets scissors in right and forceps in left.
Surgeon grabs ligament with forceps and cuts with scissors.

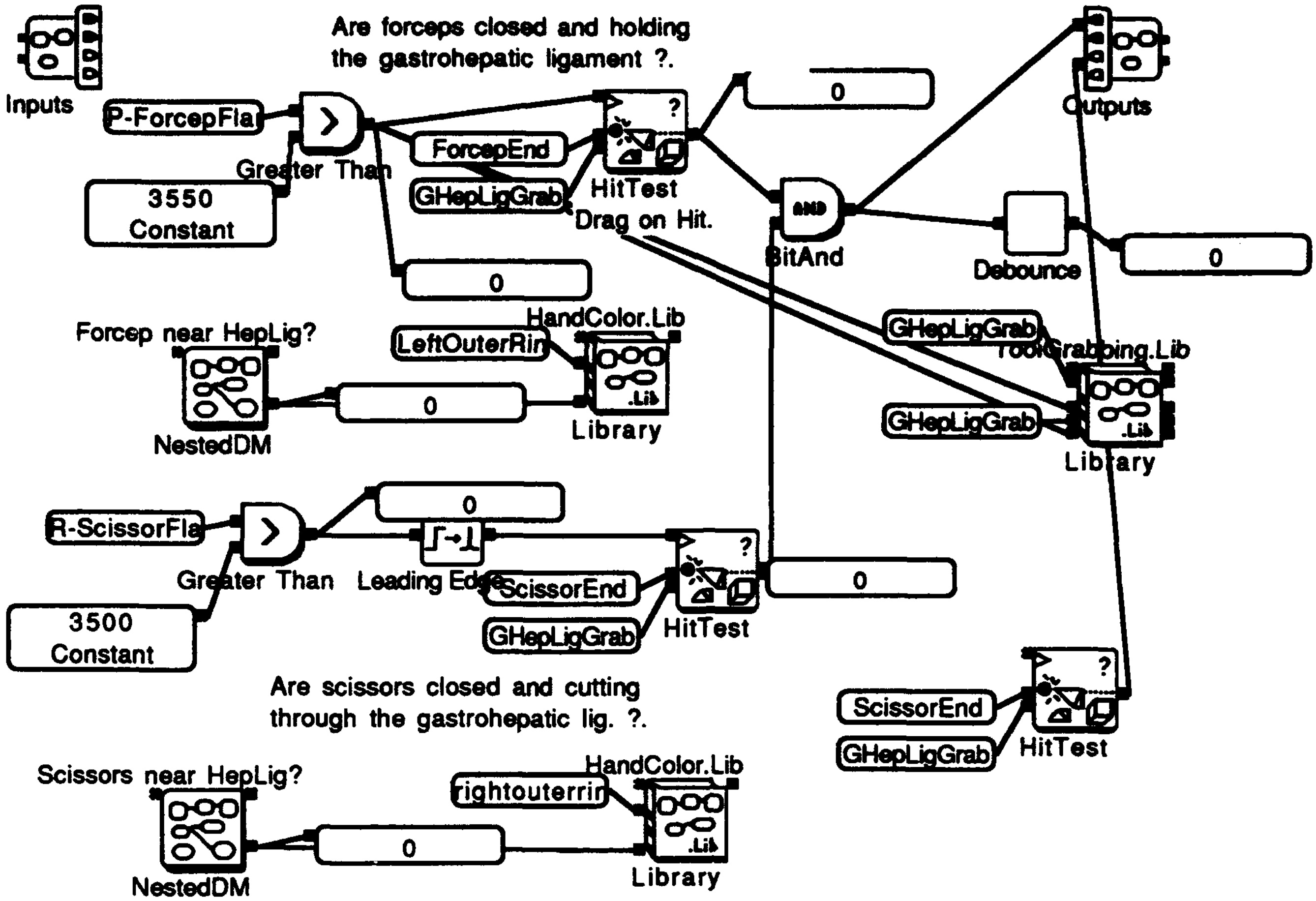

Inputs
ForcepGrab
GetField
8
18
-58
1800
0
0
Outputs
ForcepGrab
gx
gy
gz
SetField
8
18
-58
X
Y
Z
ForcepGrab
gV
gP
gR
SetField
1800
0
0
X1
Y1
Z1
Not
ForcepFlare
SetField
3599
Constant
ForcepFlare
SetField
3530
Constant

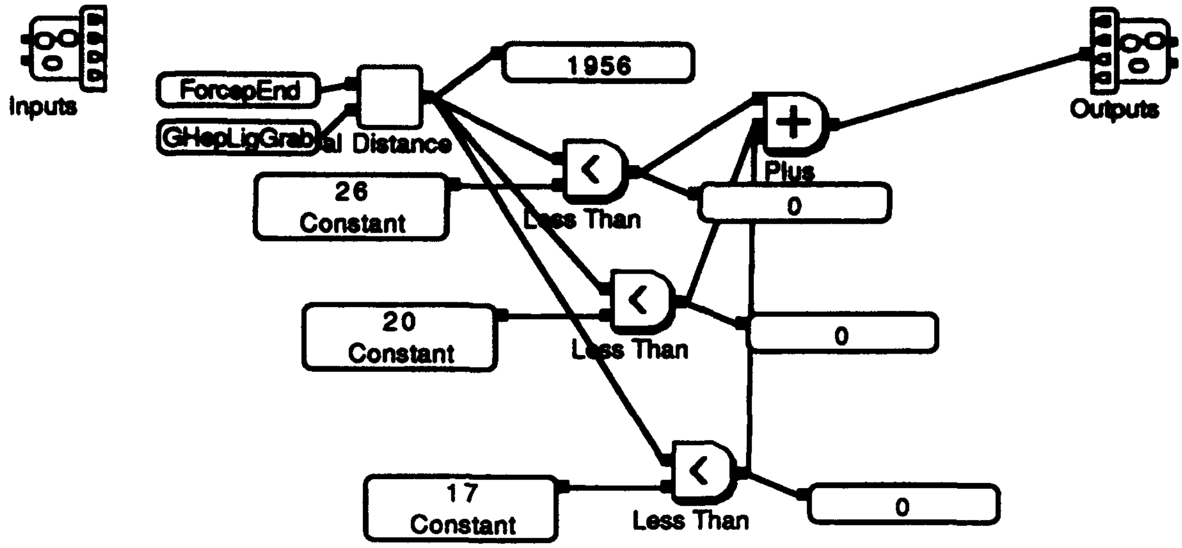

Inputs
Clock
Outputs

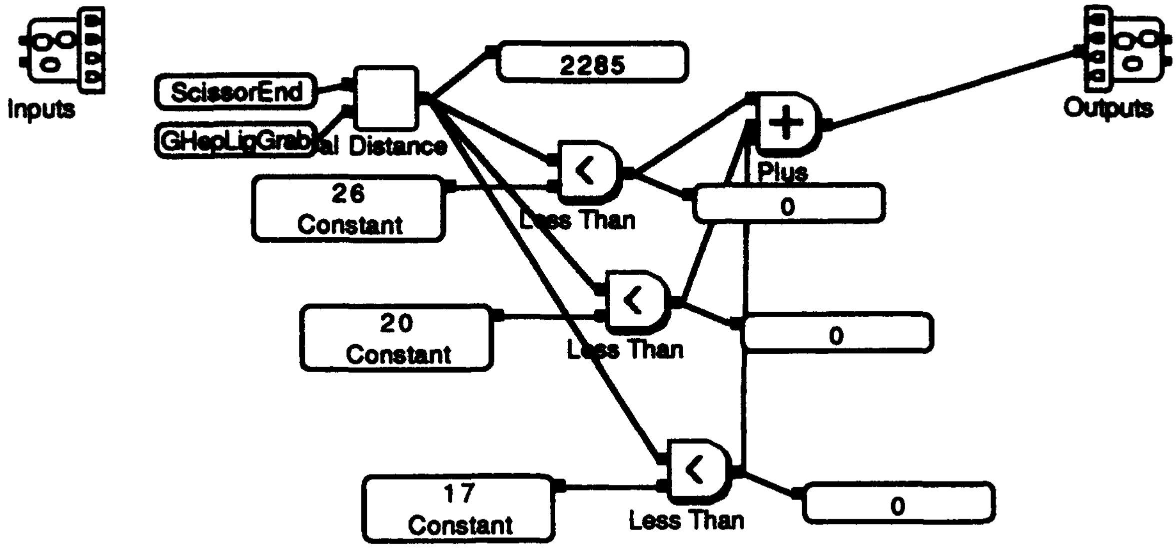

Inputs
Pause for 4 seconds
NestedDM
0
Outputs
HarringtonG
-565
Constant
-319
Constant
-1116
Constant
gx
gy
gz
SetField
1220
Constant
P-LiverRota
HarringtonG
gV
gP
gR
SetField
1689
Constant
3266
tant
3585
Constant
P-LiverRota
1200
Sets the liver to the flipped-up state.


Inputs
ScissorGrab
GetField
10
20
-60
1800
0
0
Outputs
ScissorGrab
gx
gy
gz
SetField
10
20
-62
X
Y
Z
ScissorGrab
gV
gP
gR
SetField
1800
0
0
X1
Y1
Z1
Not
ScissorFlare
SetField
3599
Constant
ScissorFlare
SetField
3530
Constant


Inputs
-3000
Constant
z-FatSlide1
Outputs


Are forceps closed and holding
the gastrohepatic ligament ?.
Inputs
P-ForcepFla
Greater Than
3550
Constant
ForcepEnd
GHepLigGrab
HitTest
Drag on Hit.
0
0
BitAnd
Outputs
Debounce
0
Forcep near HepLig?
NestedDM
LeftOuterRin
HandColor.Lib
Library
0
GHepLigGrab
ToolGrabbing.Lib
GHepLigGrab
Library
R-ScissorFla
Greater Than
3500
Constant
0
Leading Edge
ScissorEnd
GHepLigGrab
HitTest
0
Are scissors closed and cutting
through the gastrohepatic lig. ?.
ScissorEnd
GHepLigGrab
HitTest
Scissors near HepLig?
NestedDM
rightouterrin
HandColor.Lib
0
Library

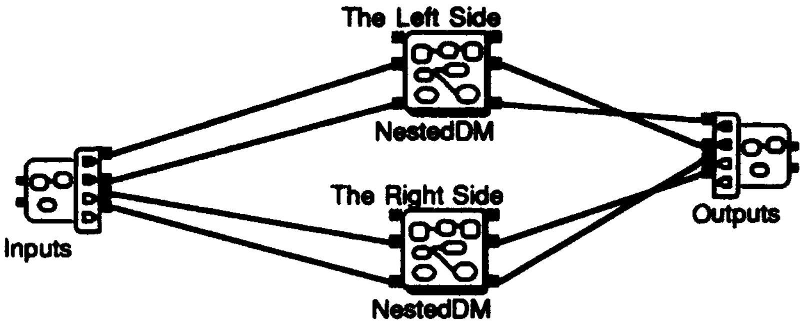

Inputs
ForcepEnd
GHepLigGrab
al Distance
1956
26
Constant
Less Than
Plus
0
Outputs
20
Constant
Less Than
0
17
Constant
Less Than
0



Inputs
ScissorEnd
GHepLigGrab
al Distance
2285
26
Constant
Less Than
Plus
0
20
Constant
Less Than
0
17
Constant
Less Than
0
Outputs

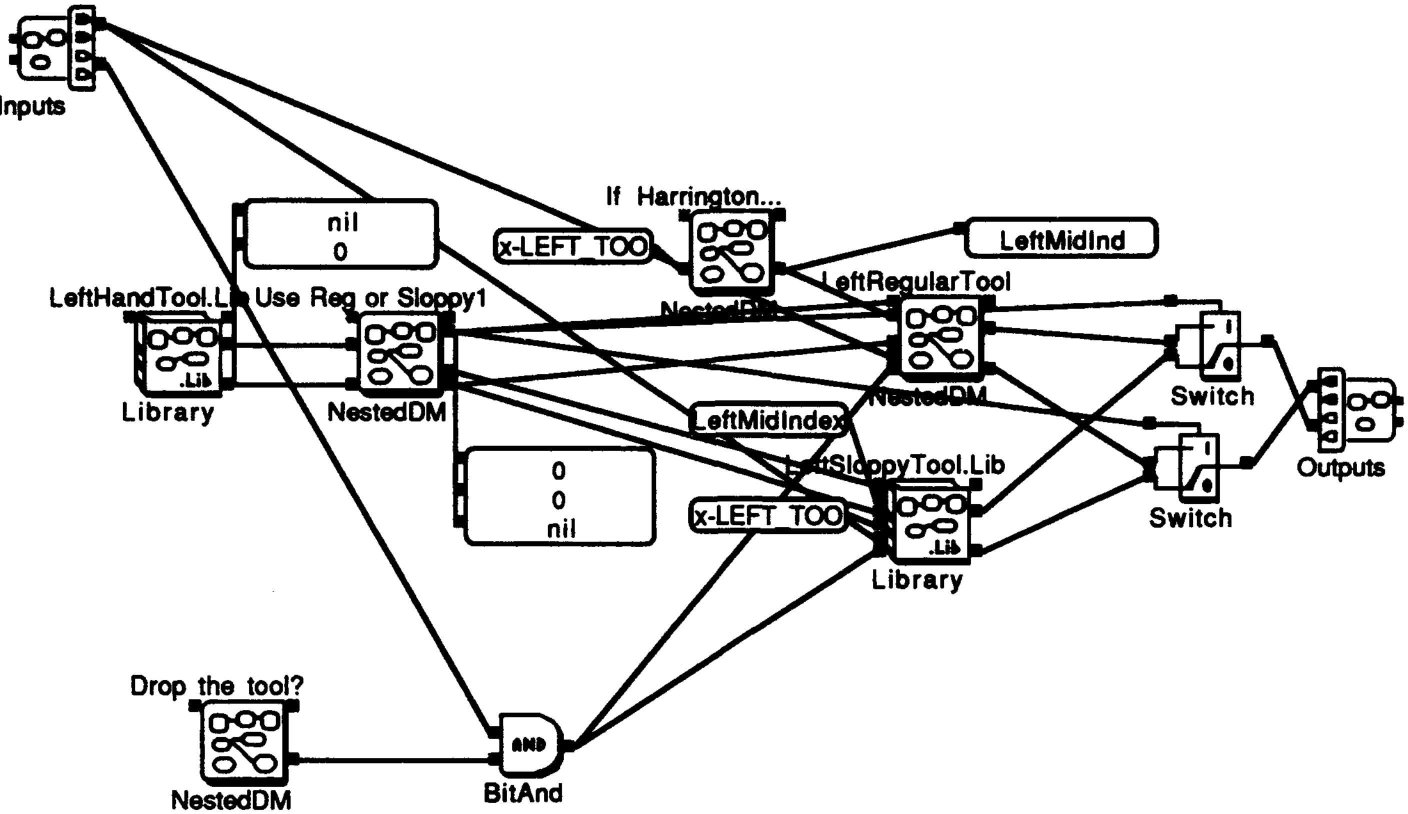
Inputs

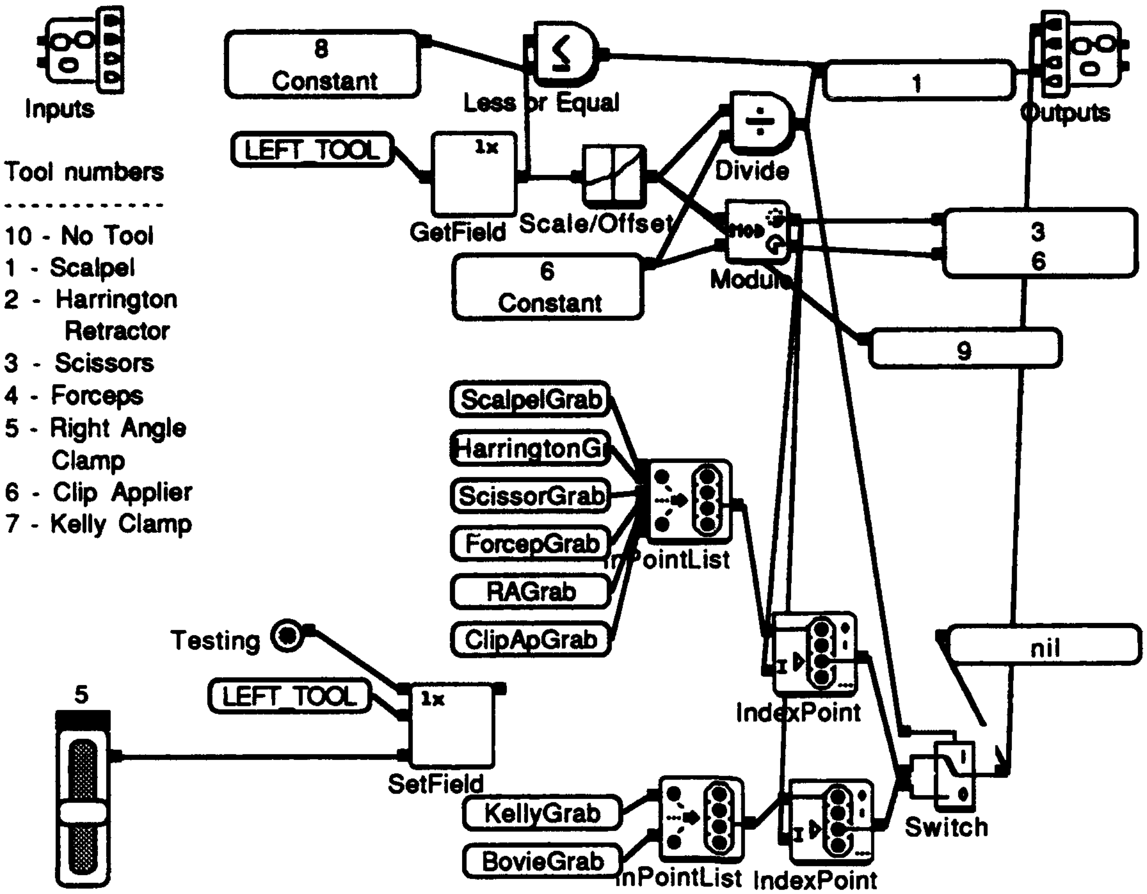
1 - Objects the Left tool can grab in this state
2 - Whether the Left tool should be able to grab right now
3 - Objects the Right tool can grab in this state
4 - Whether the Right tool should be able to grab right now



Outputs
1- If an object is being grabbed by the left tool
2- What object is being grabbed by the left tool
3- If an object is being grabbed by the right tool
4- What object is being grabbed by the right tool

Makes the tools that are in each hand follow the index finger.


Inputs
nil
0
If Harrington...
x-LEFT_TOO
LeftMidInd
LeftHandTool.Lib
Use Reg or Sloppy1
LeftRegularTool
Library
NestedDM
NestedDM
NestedDM
Switch
LeftMidIndex
Outputs
0
0
nil
LeftSloppyTool.Lib
x-LEFT_TOO
Switch
Library
Drop the tool?
NestedDM
BitAnd



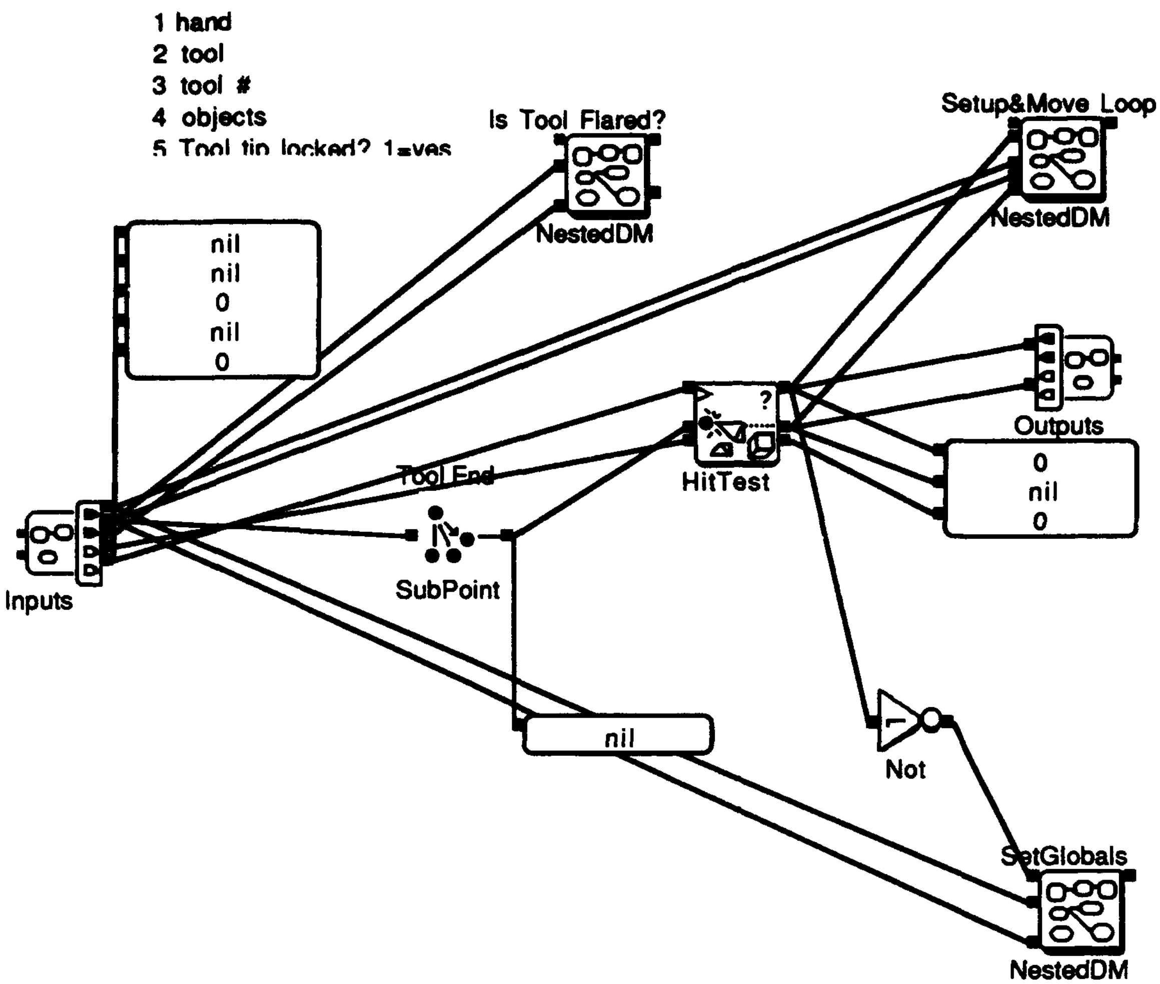
Tool numbers

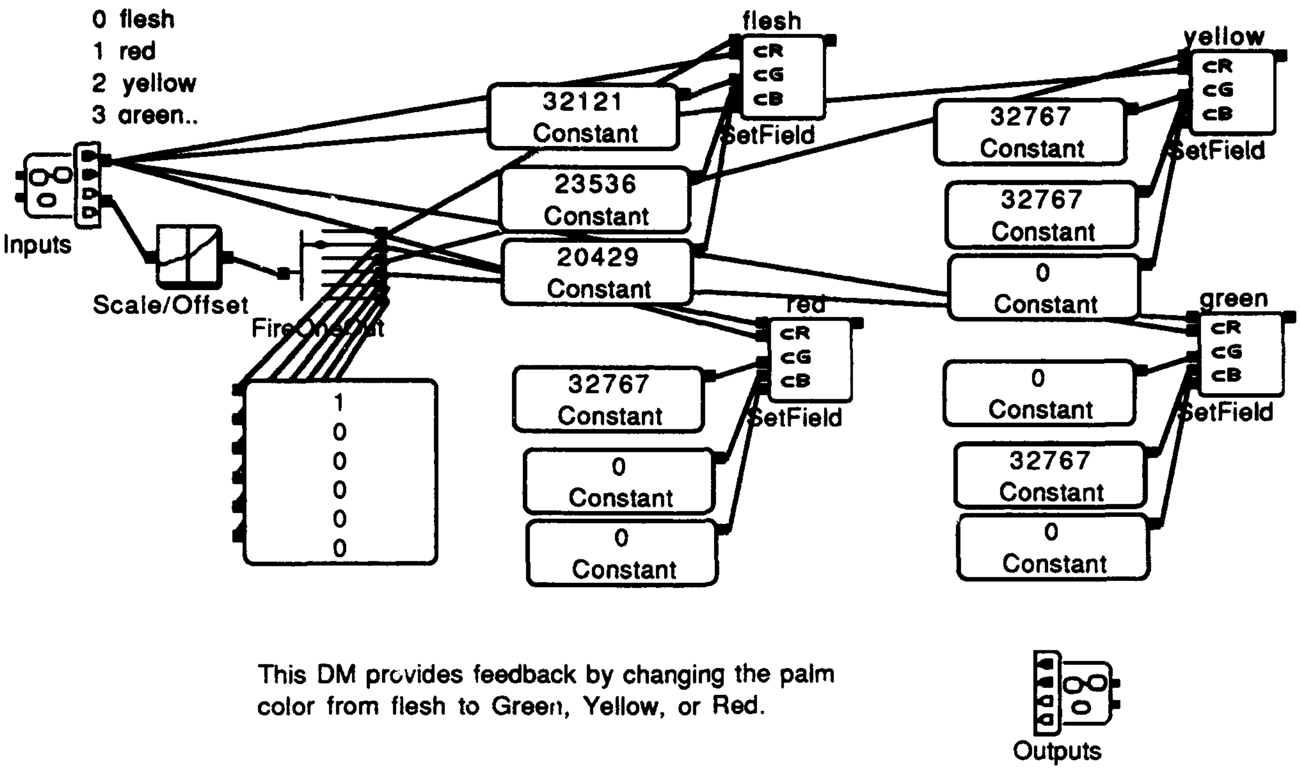
- - - - - - - - - - -

10 - No Tool
1 - Scalpel
2 - Harrington Retractor
3 - Scissors
4 - Forceps
5 - Right Angle Clamp
6 - Clip Applier
7 - Kelly Clamp

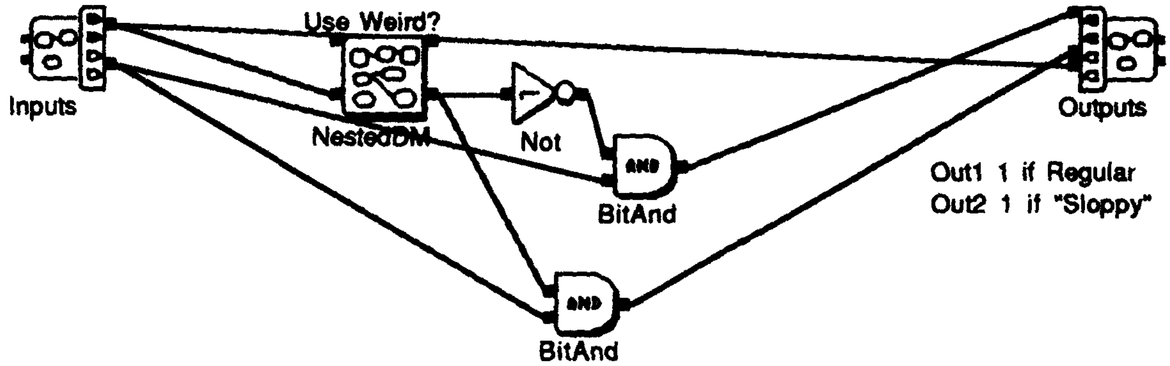
The point TOOL uses it's local x and y values for:
x - Tool number in left hand
y - Tool number in right hand

Tool currently in left hand.
Is a tool in the left hand?.

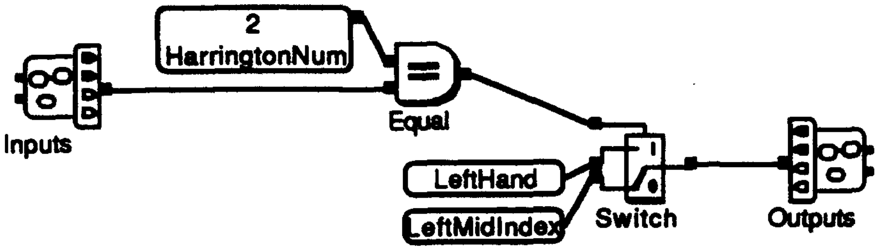

1 hand
2 tool
3 tool #
4 objects
5 Tool tip locked? 1=yes
Is Tool Flared?
NestedDM
Setup&Move Loop
NestedDM
nil
nil
0
nil
0
Outputs
0
nil
0
HitTest
Tool End
SubPoint
Inputs
nil
Not
SetGlobals
NestedDM

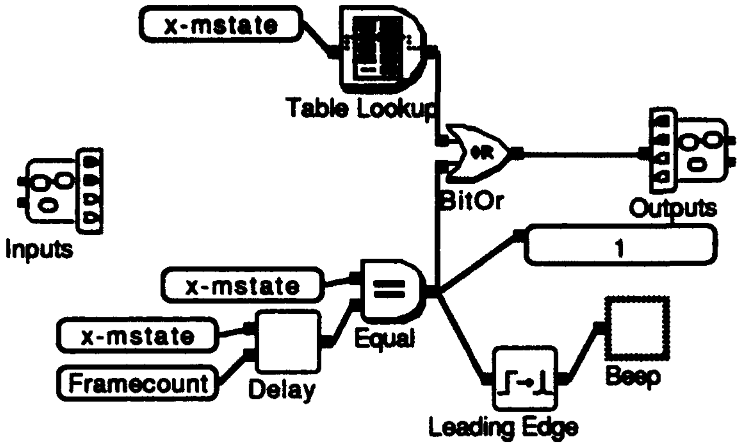


This DM provides feedback by changing the palm color from flesh to Green, Yellow, or Red.



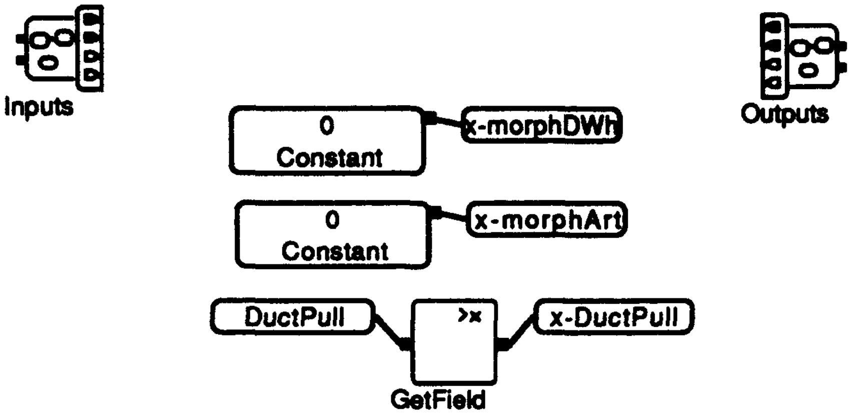
Use Weird?
Inputs
NestedDM
Not
BitAnd
BitAnd
Outputs
Out1 1 if Regular
Out2 1 if "Sloppy"

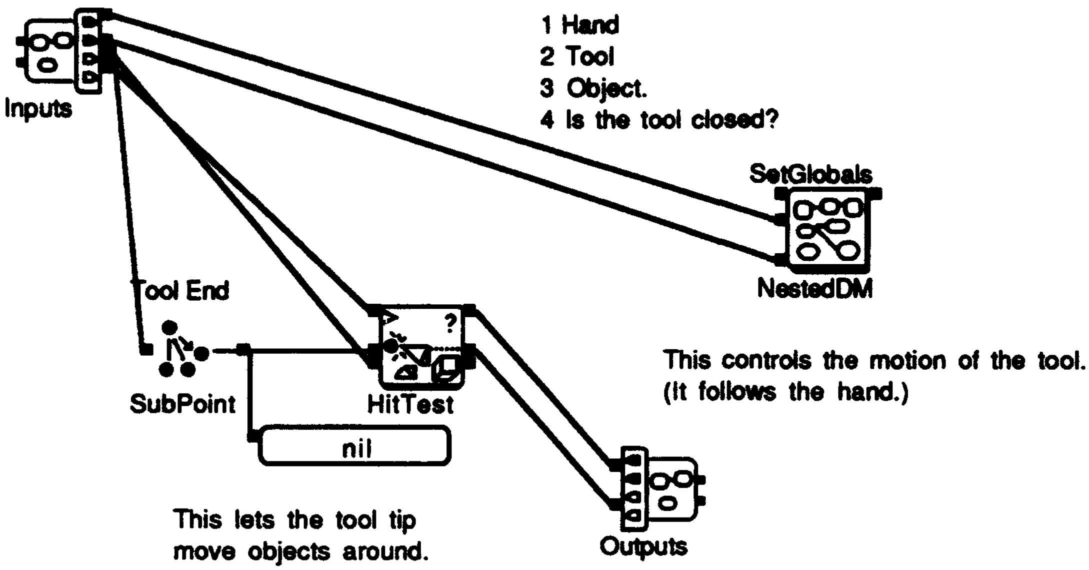

2
HarringtonNum
Inputs
Equal
LeftHand
LeftMidIndex
Switch
Outputs



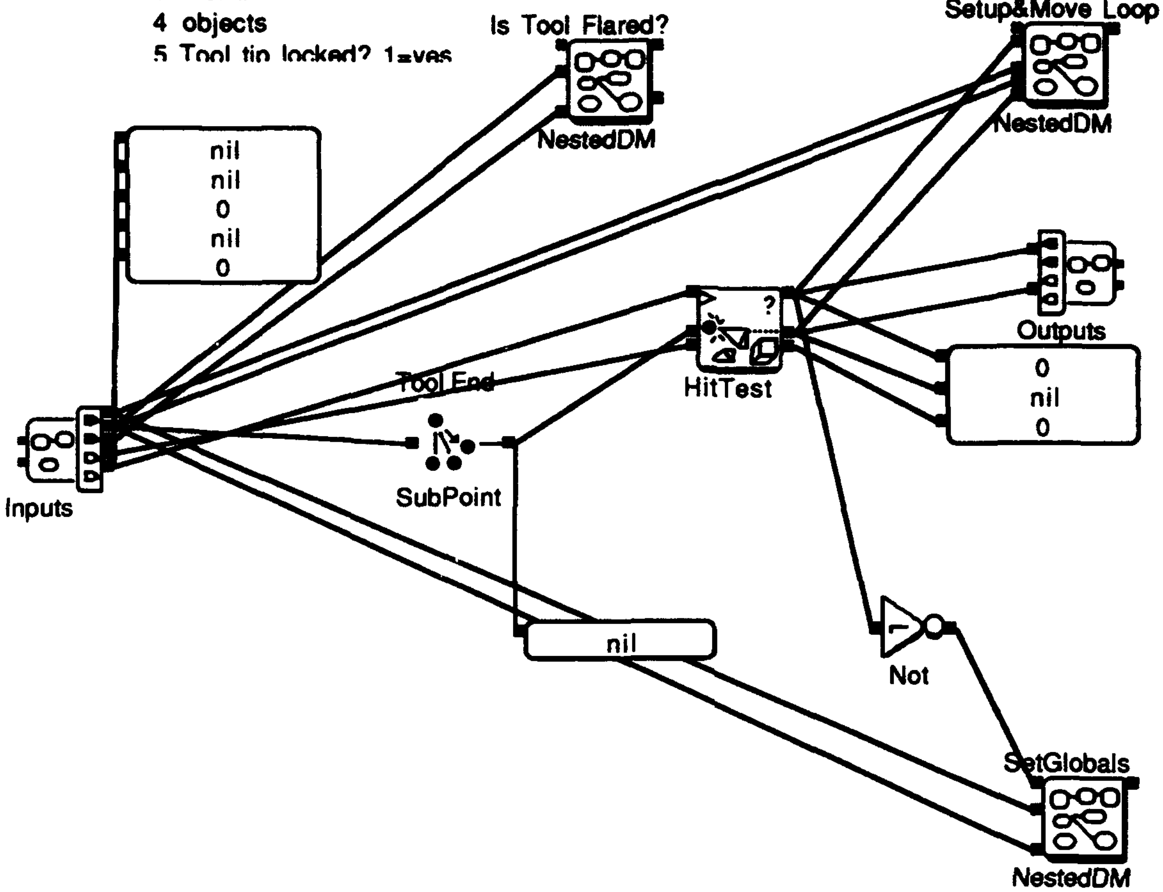
If the machine state changes and the new state isn't 8, 10, 14 then output a zero to make the existing tool/organ be dropped.

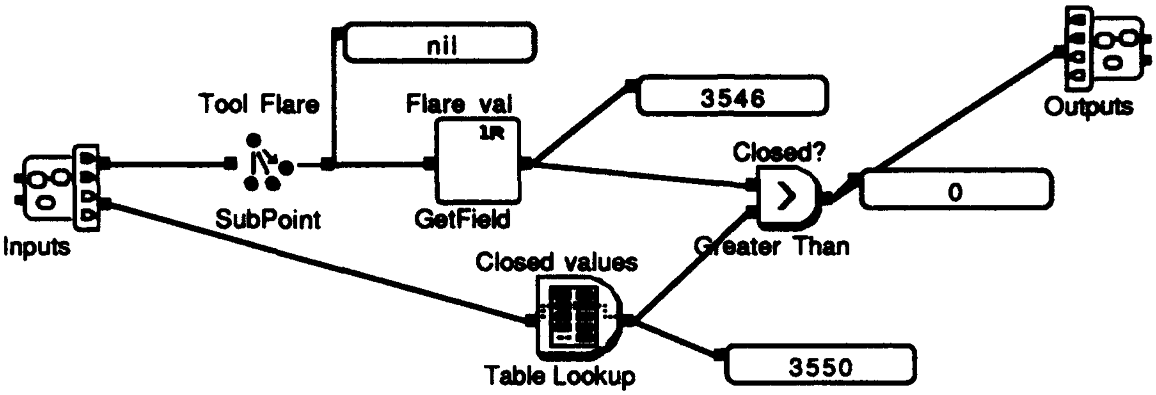
.

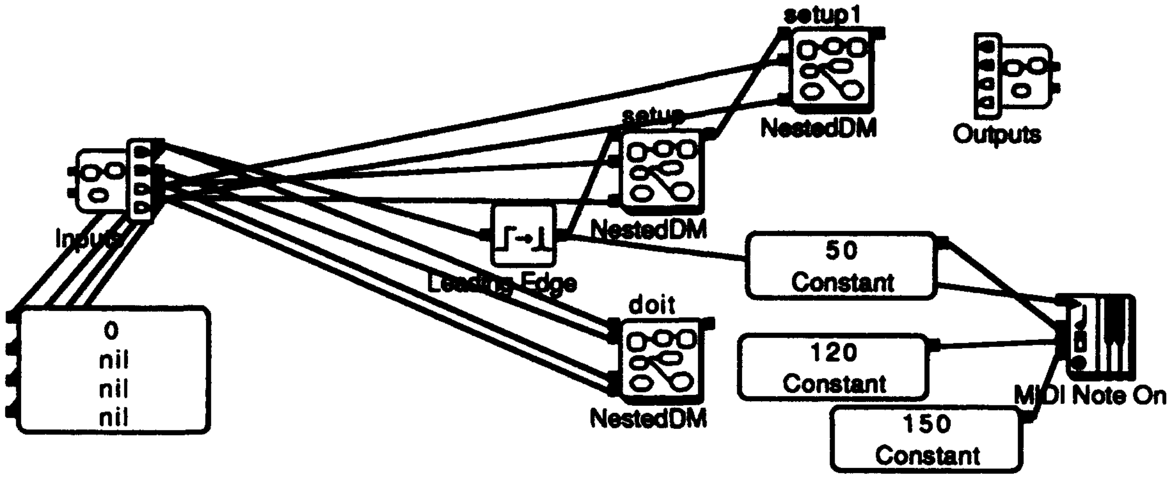

Inputs
Outputs
0
Constant
x-morphDWh
0
Constant
x-morphArt
DuctPull
>x
GetField
x-DuctPull

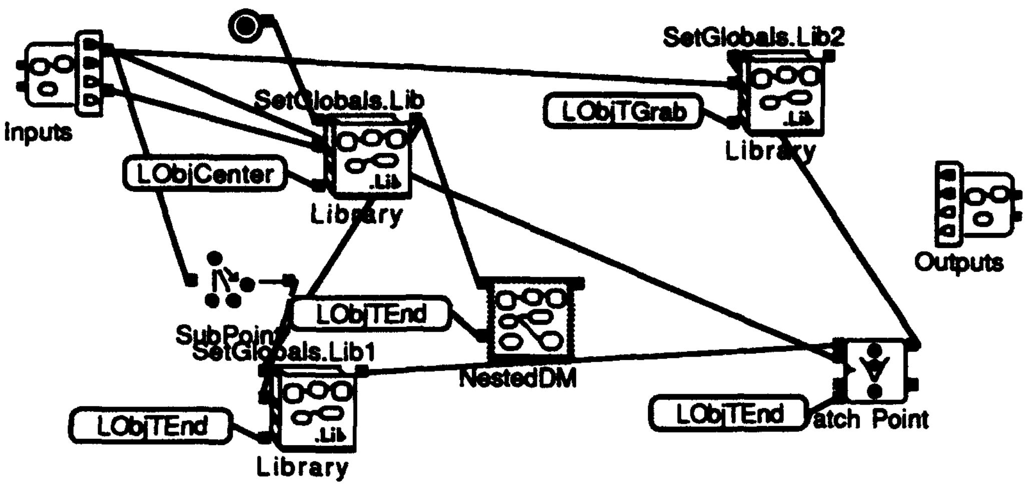

1 Hand
2 Tool
3 Object.
4 Is the tool closed?
Inputs
SetGlobals
NestedDM
Tool End
SubPoint
HitTest
nil
Outputs
This controls the motion of the tool.
(It follows the hand.)
This lets the tool tip
move objects around.

1 hand
2 tool
3 tool #
4 objects
5 Tool tip locked? 1=yes

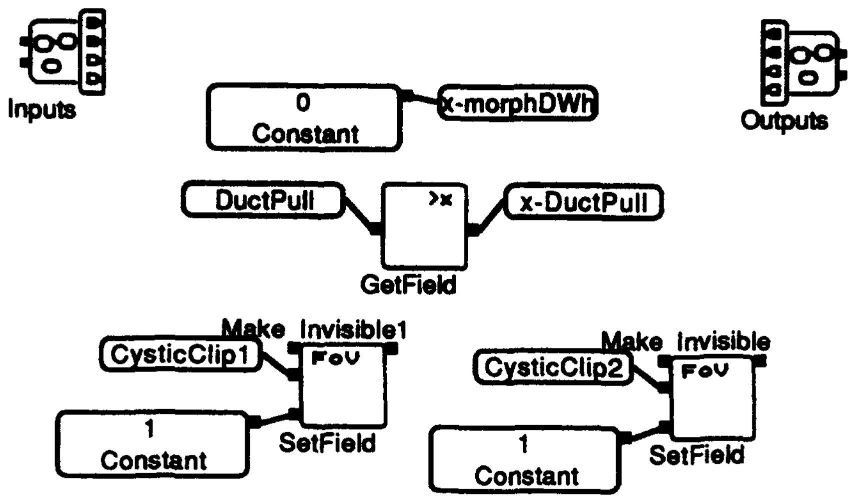


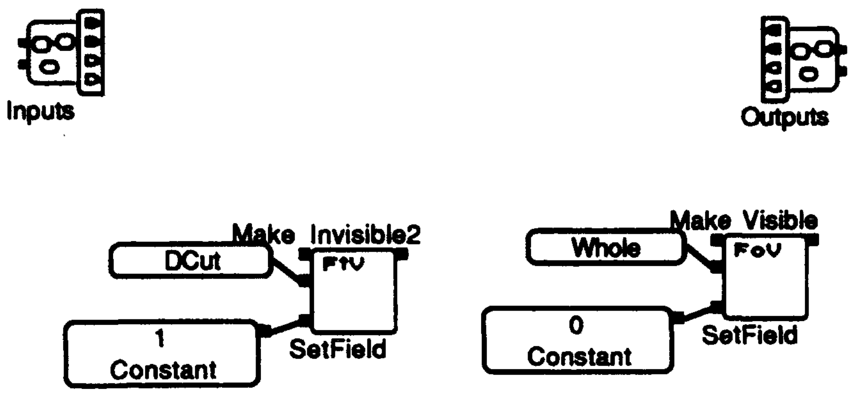

nil
Tool Flare
Flare val
1R
3546
Outputs
Closed?
Inputs
SubPoint
GetField
0
Greater Than
Closed values
Table Lookup
3550

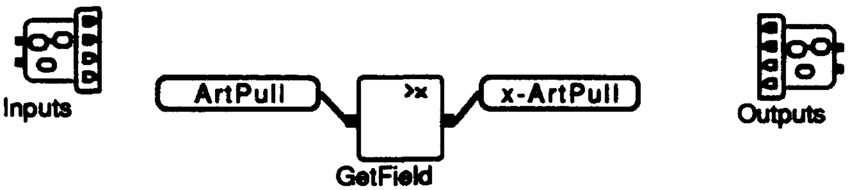

setup1
NestedDM
Outputs
setup
Inputs
NestedDM
50
Constant
Leading Edge
doit
0
nil
nil
nil
120
Constant
MIDI Note On
NestedDM
150
Constant



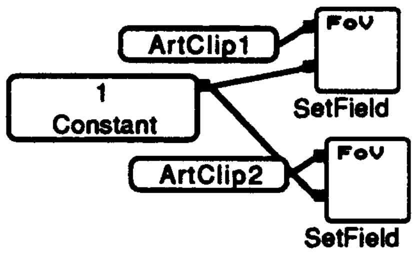
SetGlobals.Lib2
Inputs
SetGlobals.Lib
LObjTGrab
LObjCenter
Library
Library
Outputs
SubPoint
LObjTEnd
SetGlobals.Lib1
NestedDM
LObjTEnd
LObjTEnd
Library

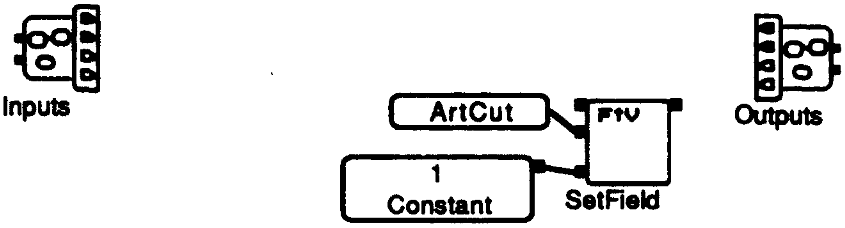

Inputs
0
Constant
x-morphDWh
Outputs
DuctPull
>x
x-DuctPull
GetField
Make Invisible1
CysticClip1
FoV
1
Constant
SetField
Make Invisible
CysticClip2
FoV
1
Constant
SetField


Inputs
Outputs
Make Invisible2
DCut
FtV
1
Constant
SetField
Make Visible
Whole
FoV
0
Constant
SetField

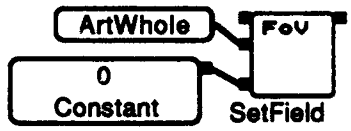


Make clips invisible.

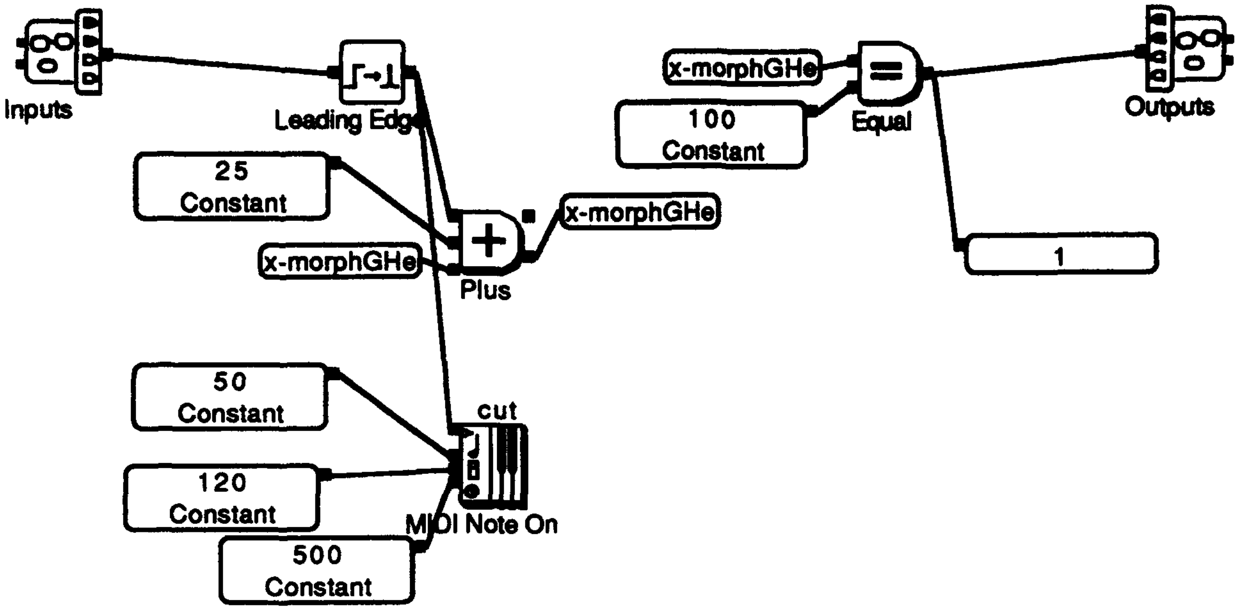




Turn the Cut tree invisible.

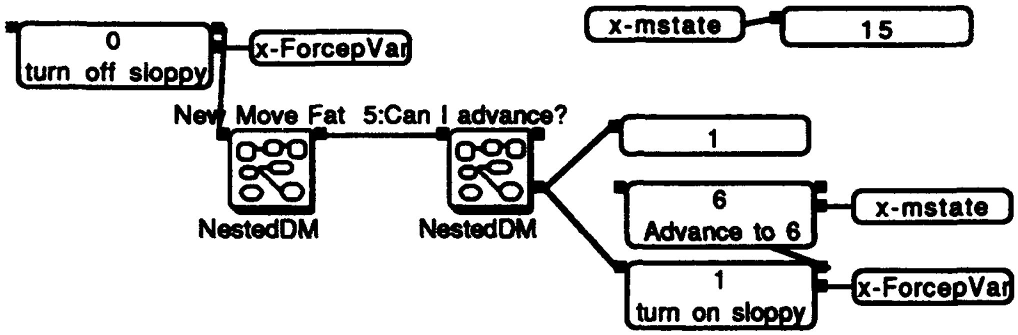


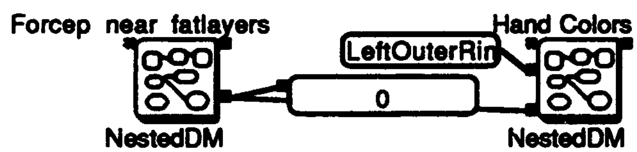
Turn the whole morph parent visible
(making the children but not the clips invisible)


Inputs
Leading Edge
25
Constant
x-morphGHe
Plus
x-morphGHe
50
Constant
cut
120
Constant
MIDI Note On
500
Constant
x-morphGHe
100
Constant
Equal
Outputs
1

Synopsis:
Surgeon drops scissors.
Surgeon pulls away 3 fat layers with forceps in sequence.

Requirements:
Forceps touch fat and move from X to Y, making the layer invisible.
True for all three layers.



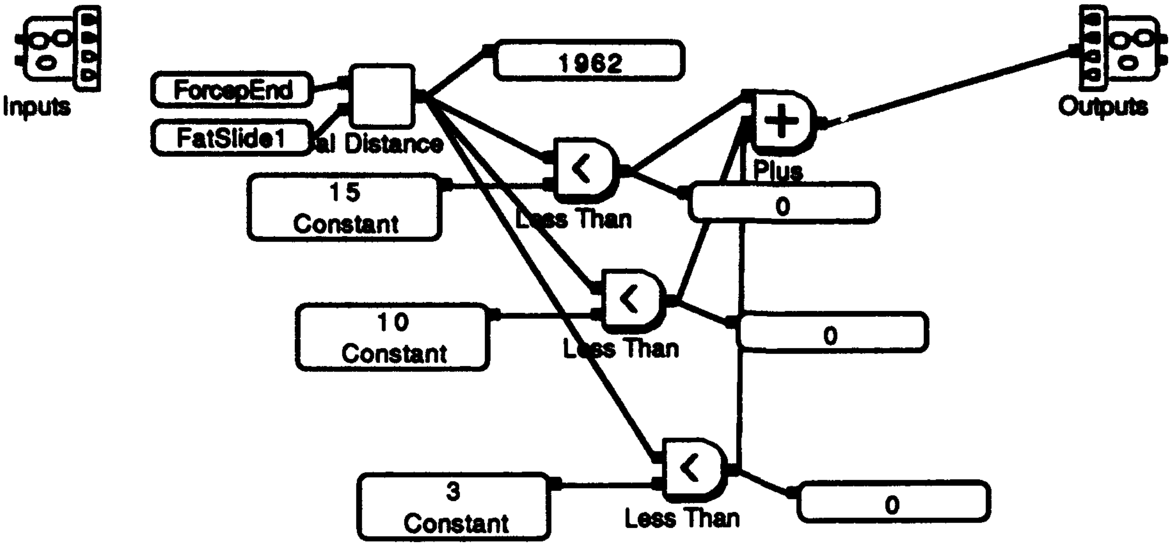


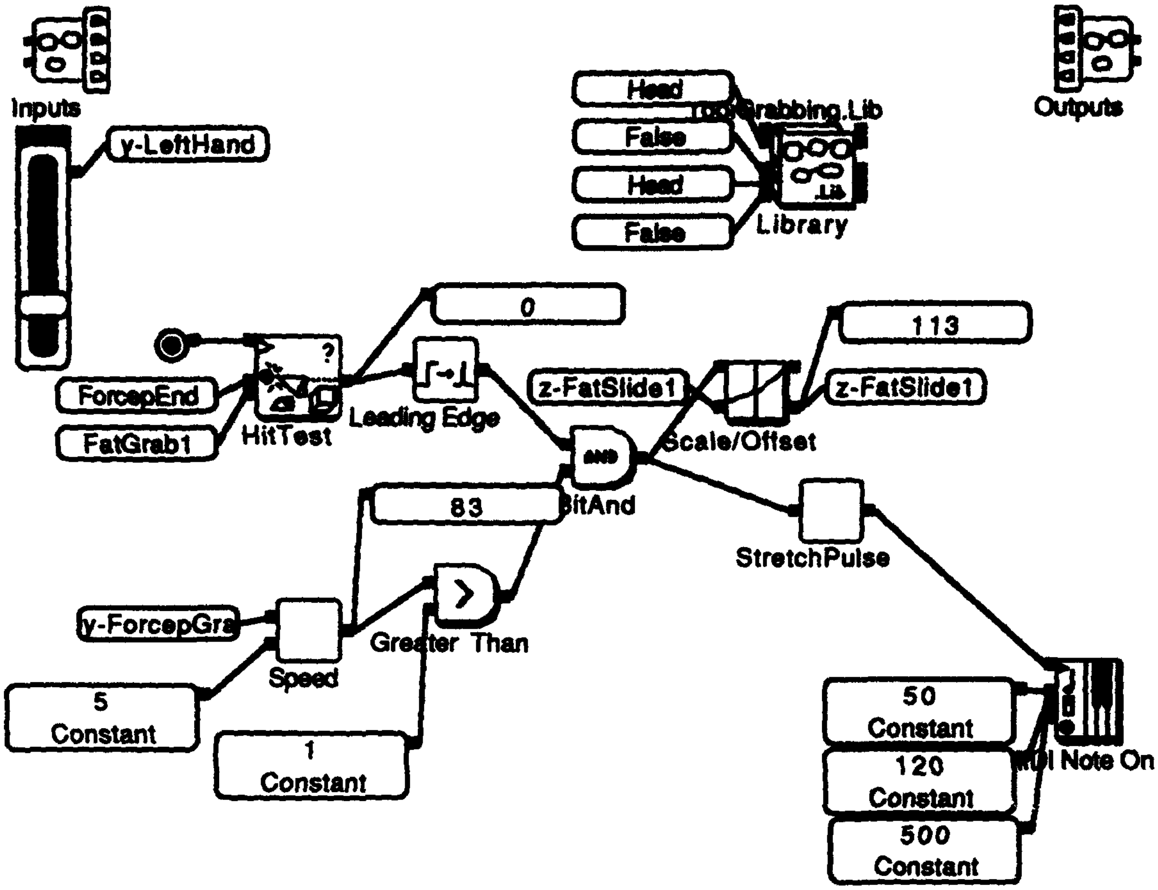
Inputs

Outputs

Move forceps from one hittest to the next.

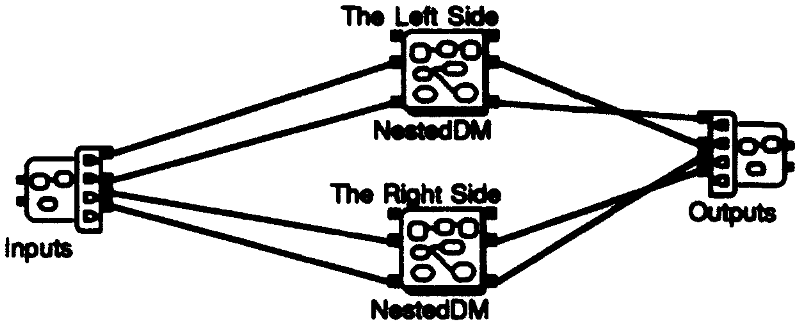
The above constants are a cheat. We should actually move the tools for debug purposes, not just jump to the end result.


Inputs
ForcepEnd
FatSlide1
al Distance
1962
15
Constant
Less Than
0
Plus
Outputs
10
Constant
Less Than
0
3
Constant
Less Than
0


Inputs
Outputs
y-LeftHand
Head
False
Head
False
ToolGrabbing.Lib
Library
0
113
ForcepEnd
FatGrab1
HitTest
Leading Edge
z-FatSlide1
z-FatSlide1
Scale/Offset
BitAnd
83
StretchPulse
y-ForcepGra
Speed
Greater Than
5
Constant
1
Constant
50
Constant
120
Constant
500
Constant
MIDI Note On

Inputs

1 - Objects the Left tool can grab in this state
2 - Whether the Left tool should be able to grab right now
3 - Objects the Right tool can grab in this state
4 - Whether the Right tool should be able to grab right now

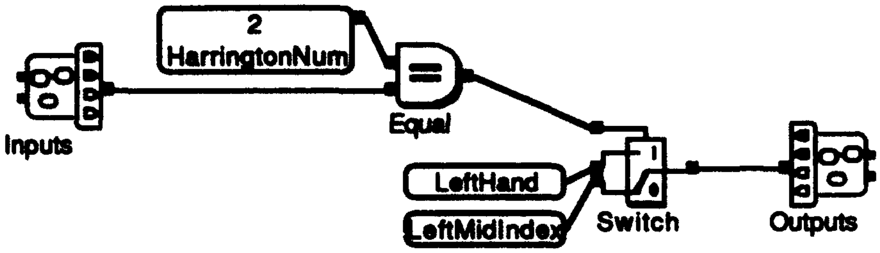


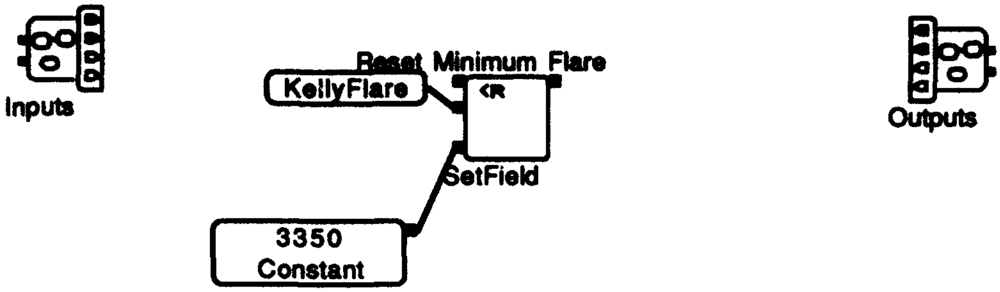
Outputs
1- If an object is being grabbed by the left tool
2- What object is being grabbed by the left tool
3- If an object is being grabbed by the right tool
4- What object is being grabbed by the right tool

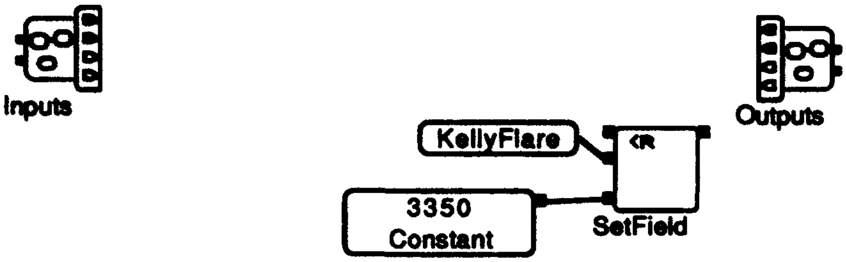
Makes the tools that are in each hand follow the index finger.

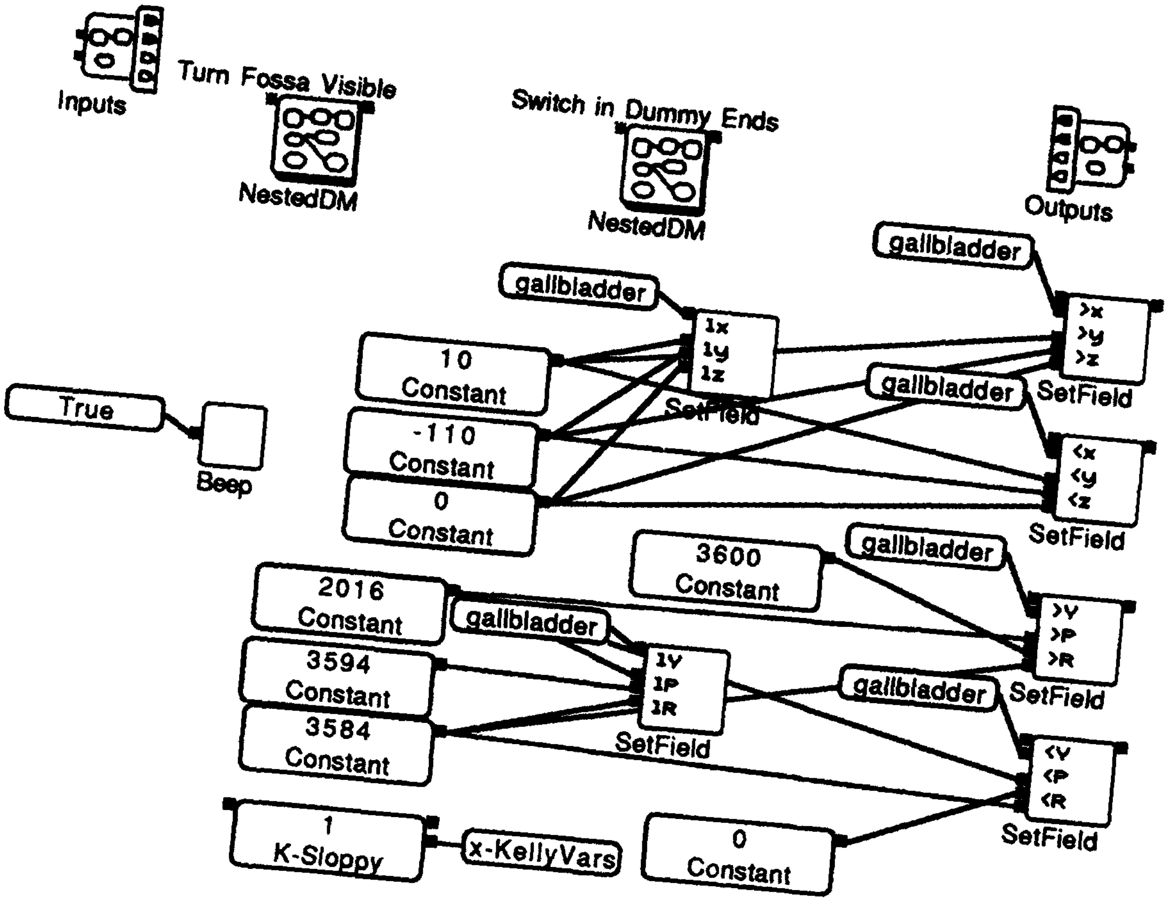
Inputs

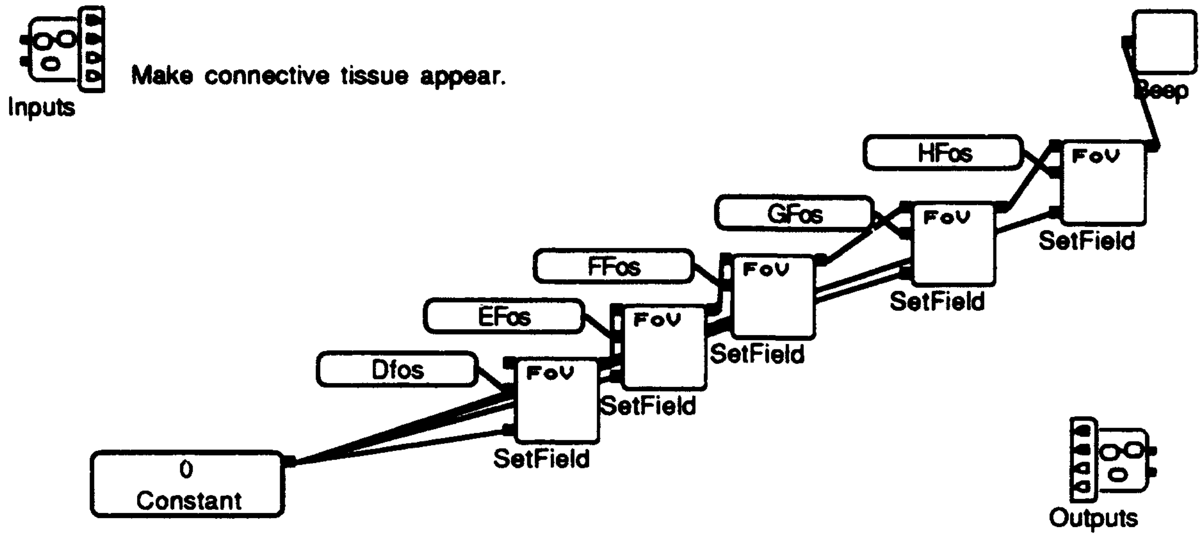
Outputs

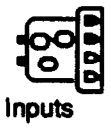

2
HarringtonNum
Inputs
Equal
LeftHand
LeftMidIndex
Switch
Outputs

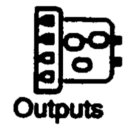

Inputs
Reset Minimum Flare
KellyFlare
SetField
3350
Constant
Outputs


Inputs
Outputs
KellyFlare
3350
Constant
SetField


Inputs
Turn Fossa Visible
NestedDM
Switch in Dummy Ends
NestedDM
Outputs
gallbladder
gallbladder
1x
1y
1z
SetField
10
Constant
-110
Constant
0
Constant
True
Beep
>x
>y
>z
SetField
gallbladder
<x
<y
<z
SetField
3600
Constant
gallbladder
2016
Constant
gallbladder
3594
Constant
3584
Constant
1V
1P
1R
SetField
>V
>P
>R
SetField
gallbladder
<V
<P
<R
SetField
1
K-Sloppy
x-KellyVars
0
Constant

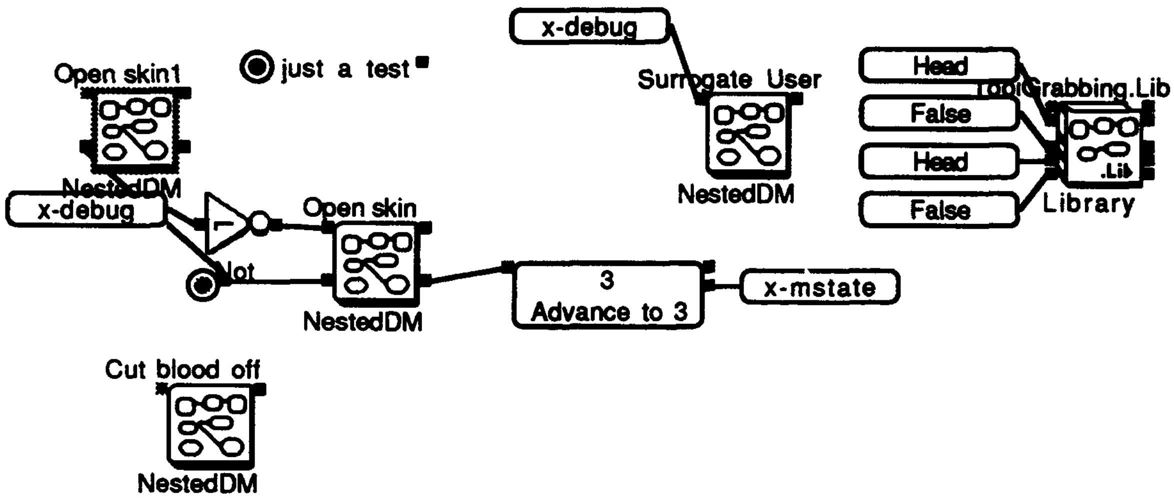

Inputs
Make connective tissue appear.
Beep
HFos
FoV
GFos
FoV
SetField
FFos
FoV
SetField
EFos
FoV
SetField
Dfos
FoV
SetField
SetField
0
Constant
Outputs



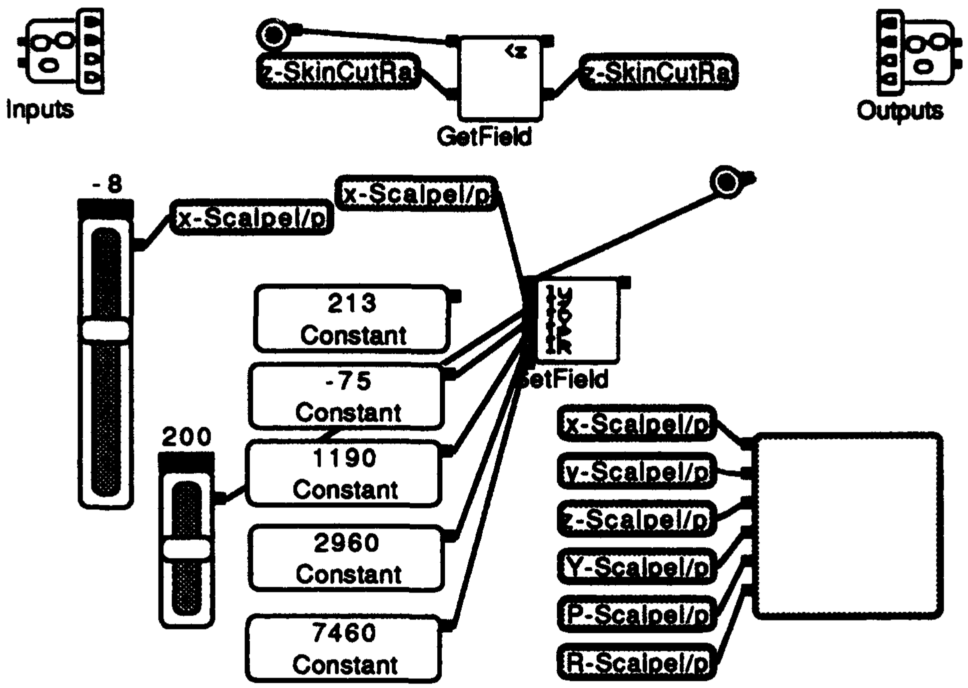


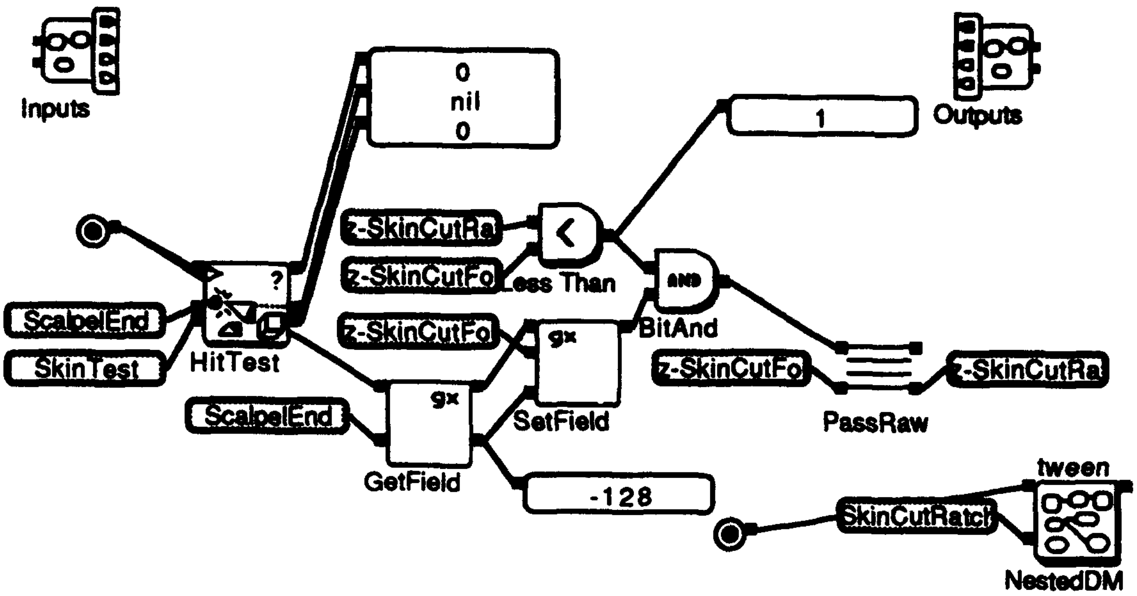
Synopsis:
Surgeon asks nurses to pull back skin, muscle, ribs.

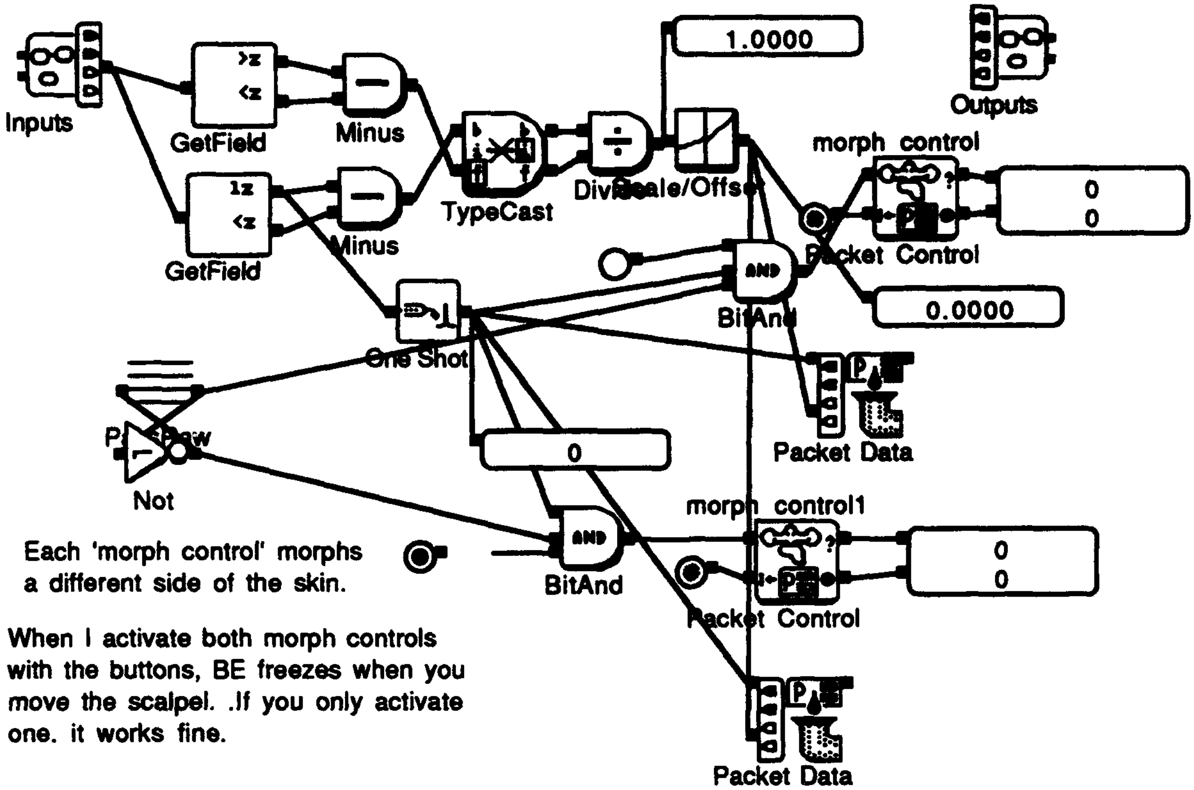
Requirements:
Speech command which triggers opening of abdominal wall.




Inputs
Ghost Scalpel
NestedDM
OpenSkin
NestedDM
Outputs

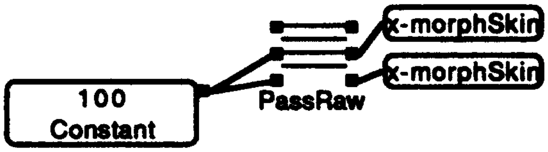

Inputs
z-SkinCutRa
GetField
z-SkinCutRa
Outputs
-8
x-Scalpel/p
x-Scalpel/p
213
Constant
-75
Constant
200
1190
Constant
2960
Constant
7460
Constant
etField
x-Scalpel/p
y-Scalpel/p
z-Scalpel/p
Y-Scalpel/p
P-Scalpel/p
R-Scalpel/p


Inputs
0
nil
0
1
Outputs
z-SkinCutRa
z-SkinCutFo
Less Than
AND
BitAnd
ScalpelEnd
SkinTest
HitTest
z-SkinCutFo
gx
SetField
z-SkinCutFo
z-SkinCutRa
PassRaw
ScalpelEnd
gx
GetField
-128
tween
SkinCutRatch
NestedDM



Each 'morph control' morphs
a different side of the skin.

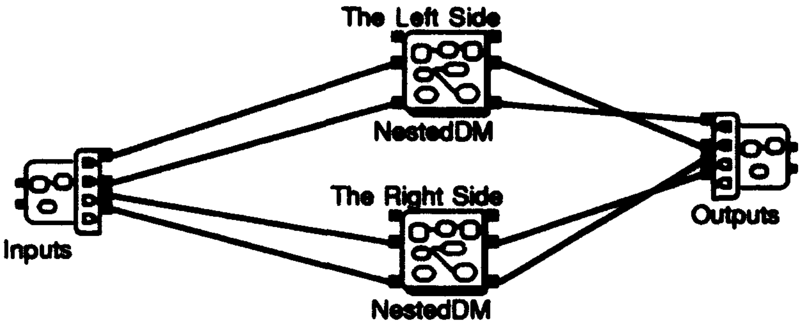
When I activate both morph controls with the buttons, BE freezes when you move the scalpel. .If you only activate one. it works fine.



Sets the liver to the flipped-up state.

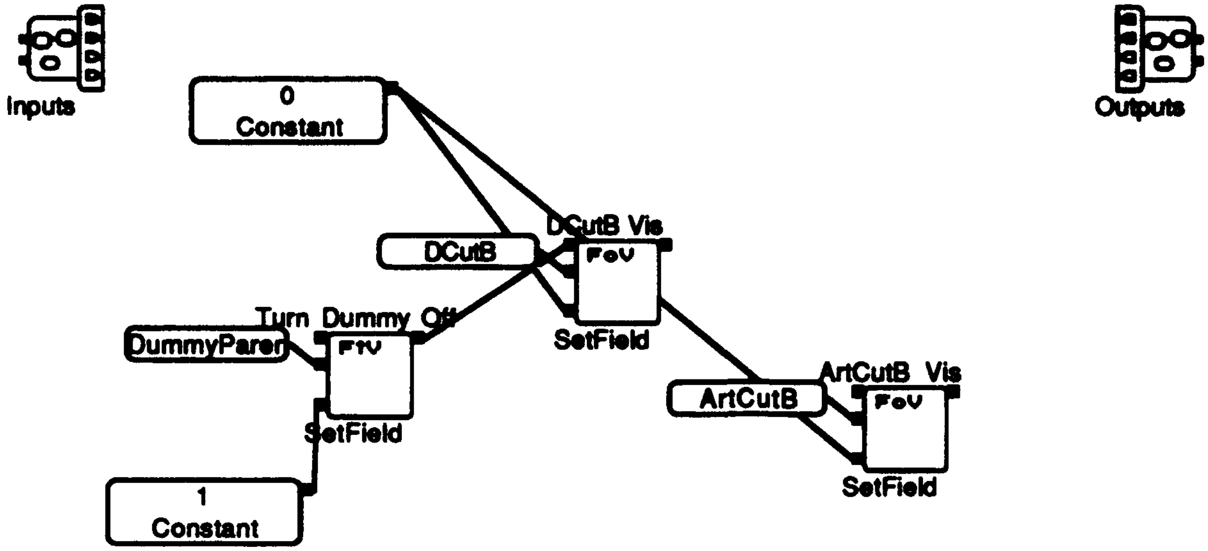
Inputs

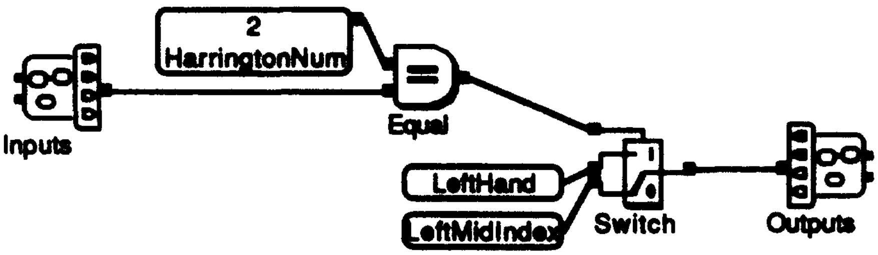
1 - Objects the Left tool can grab in this state
2 - Whether the Left tool should be able to grab right now
3 - Objects the Right tool can grab in this state
4 - Whether the Right tool should be able to grab right now



Outputs
1- If an object is being grabbed by the left tool
2- What object is being grabbed by the left tool
3- If an object is being grabbed by the right tool
4- What object is being grabbed by the right tool

Makes the tools that are in each hand follow the index finger.


Inputs
Outputs
0
Constant
DCutB
DCutB Vis
FoV
SetField
Turn Dummy Off
DummyParen
FtV
SetField
1
Constant
ArtCutB
ArtCutB Vis
FoV
SetField


2
HarringtonNum
Inputs
Equal
LeftHand
LeftMidIndex
Switch
Outputs

Inputs

Outputs

Inputs

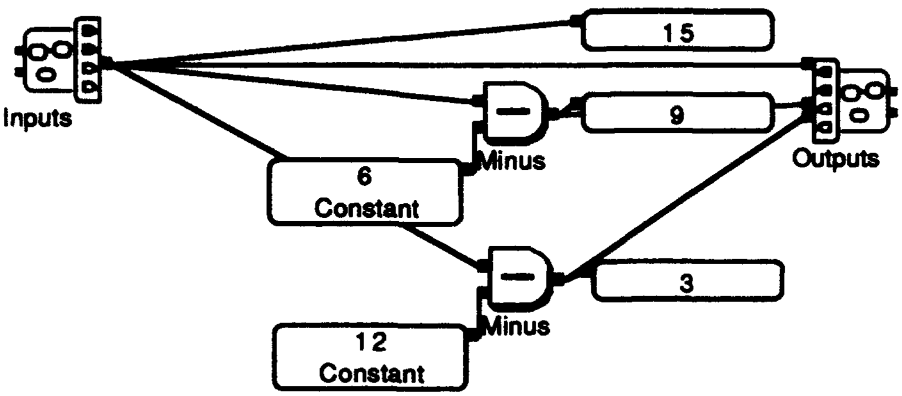
Outputs

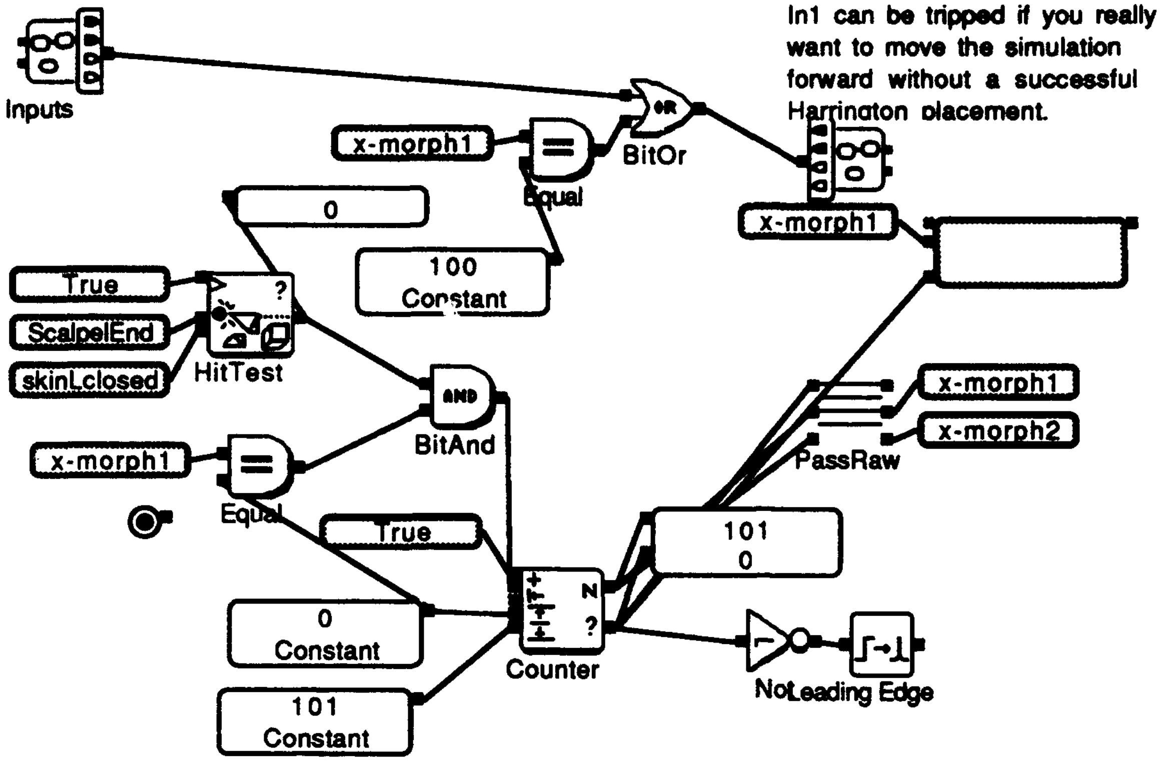

Inputs


Outputs

In1: Which state are you in?

Out1: Goes to first Fire one out.
Out2: Goes to second Fire one out.
Out3: Goes to third fire one out..

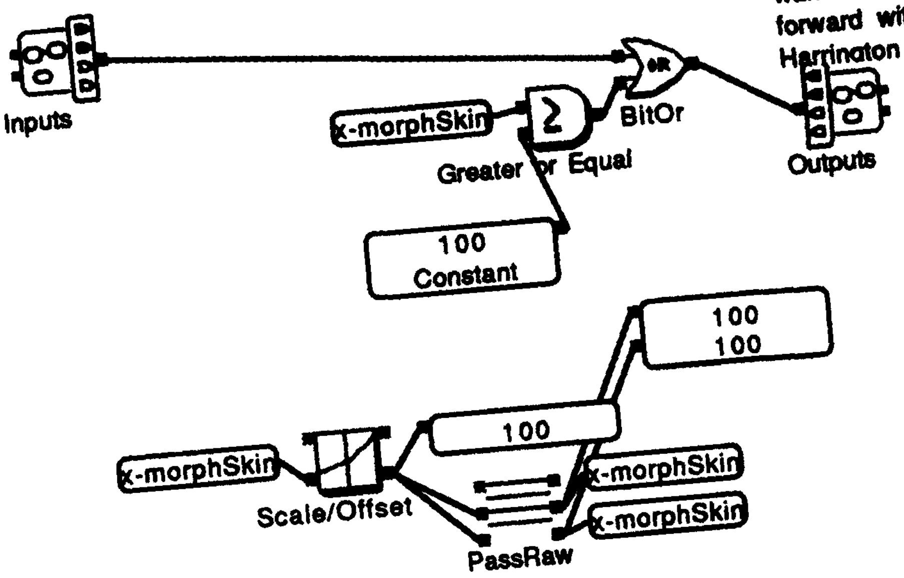




morph the two pieces of skin from 0 to 100 when the scalpel hits them.
This should be changed eventually to add retractors


Inputs
Outputs
MorphLine
True
FoV
SetField

In1 can be tripped if you really want to move the simulation forward without a successful Harrington placement.



morph the two pieces of skin from 0 to 100 when the scalpel hits them.
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